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Relationships of student gender, personal epistemological beliefs, science self-efficacy, attitude, and subjective norms to intended science class enrollment

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Relationships of student gender, personal epistemological beliefs, science self-efficacy, attitude, and subjective norms to intended science class enrollment

by

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GENERAL INTRODUCTION

Introduction

Women are underrepresented in physical science education and careers. When the term "underrepresentation" is used in this paper, it is not implied that men and women must enter science careers in proportions equal to their representation in the population. Rather, it is argued that the educational and social experiences of many girls and women in our culture discourage some, who would otherwise have been interested in training for science careers, from entering such careers. In 1986, women constituted only 15% of all employed engineers, scientists, and mathematicians in the United States, although women made up 49% of the total professional workforce (Oakes, 1990). Underrepresentation of women is not equal across all areas of science, however. In 1986, women made up 25% of people employed in the life sciences, but only 13% of those employed in physical science (National Science Foundation [NSF], 1988). The gender difference is particularly large in engineering, with females making up only 1.5% of the total number of engineers (NSF, 1980, cited in Hill, Pettus, & Hedin, 1990).

Women are less likely than men to pursue college degrees in science, with the largest gender differences in the physical sciences. Women obtain 50.8 % of the bachelors degrees awarded in life science, but only 31.3 % of the bachelors degrees in physical science, and only 16% of the bachelors degrees awarded in physics (US Department of Education, 1993).

Concerns about the differential participation of males and females in science have originated from two perspectives: one based on a predicted shortage of qualified scientists and the other concerned with gender equity and equality issues (Kahle & Meece, 1994). Concerns were raised following predictions made by the National Science Foundation in

1987 of a significant decline in the number of science bachelor's degrees awarded to students who were citizens of the United States, with a resulting drop in the number of science doctorates predicted (Rosser, 1990; Oakes, 1990). With a shortage of well-trained scientists in the United States by the mid 1990's and with demographic trends predicting fewer white males than before enrolling in college in the 1990's, science educators suggested that minority students and females would be required to fill the vacancies (Widnall, 1988).

The second perspective on differential participation of men and women in science concerns gender equity and equality issues. Concerns have been raised that girls and women do not have equal access to the economic opportunities afforded by entrance into science and engineering careers (Oakes, 1990). It has been suggested that stereotyping of science as a masculine profession, male-friendly science content and pedagogical approaches, and discrimination against women prevents females from entering science careers (Rosser, 1990).

Oakes (1990) pointed out that at least part of the reason for the underrepresentation of women in science is that compared with young men, women leave high school less well prepared to pursue degrees and careers in science. Recent statistics have suggested that the gender difference in formal high school science preparation is specific to physics. The 1992 National Assessment of Educational Progress (NAEP) report (Mullis, Dossey, Campbell, Gentile, O'Sullivan, & Latham, 1994) indicated that more girls than boys enroll in biology and chemistry classes in high school, but that the pattern reverses for physics enrollment. Fifteen percent of the 17-year-old boys in the 1992 NAEP sample had taken or were currently taking high school physics, but only 12% of the girls had taken or were taking a physics class.

Why are women underrepresented in physics and engineering? In a review of the literature on gender issues in math and science, Kahle and Meece (1994) discussed several factors that may contribute to differential participation, including cognitive abilities, sociocultural variables, home and family variables, educational variables, and student attitudes. Of particular interest to many science education researchers are the gender differences in attitudes toward science (see Gardner, 1975 and Schibeci, 1984 for reviews). Middle school and high school girls report less positive attitudes than boys toward science (Mullis & Jenkins, 1988; Simpson & Oliver, 1990; Oliver & Simpson, 1988). Attitude toward science may influence course enrollment decisions. Simpson and Oliver (1990), in a longitudinal study of middle and high school students, found that attitude at grade 10 predicted future course enrollment in science.

In a recent review of research on the affective component of science learning, Simpson, Koballa, Oliver, and Crawley (1994) noted one model emerging from decades of social psychology research, the Fishbein and Ajzen (1975) Theory of Reasoned Action, that has utility for science education research. Fishbein and Ajzen (1975; Ajzen & Fishbein, 1980) proposed a model for prediction of behavior from attitudes and perceived social support. Their theory has been applied to the study of behaviors such as voting, birth control, and weight loss. The Theory of Reasoned Action is useful in the study of high school class enrollment decisions because it allows the researcher to investigate the components of such decisions. If attitude toward enrollment and subjective norms associated with science enrollment decisions predict intent to enroll, then investigation of the beliefs that underlie attitude and subjective norms components should shed light on group differences, such as gender differences, in enrollment decisions.

Crawley and Coe (1990) applied the Theory of Reasoned Action to prediction of 100 Texas middle school students' intentions to enroll in a nonrequired high school science course during the next school year. Koballa (1988), with a sample of 94 Texas middle school girls, investigated the relationship between attitudes toward enrollment in physical science courses, perception of subjective norms concerning enrollment, and intent to enroll in a physical science course in high school. Crawley and Black (1992) applied the Theory of Planned Behavior (Ajzen, 1991) to the study of high school students' intention to enroll in physics classes. Crawley and Black used a causal modeling approach to investigate the relationships between model variables and five external variables, including grade (8-10), career goal, gender, ethnicity, and educational goal.

This dissertation addressed several questions. First, it asked if high school freshmen have different attitudes and different perceived social support in the science content areas of physics, chemistry, and biology. Second, because gender differences in science education and careers are particularly evident in the area of physics, the dissertation asked if male and female students differed in the beliefs that underlie physics course enrollment decisions. Third, the dissertation investigated the effects of science self-efficacy and personal epistemological beliefs on student beliefs about enrollment in high school physics classes.

Dissertation Organization

The dissertation consists of two papers intended to be submitted to scholarly journals. The first is a review of the literature in the area of student attitudes toward science. The review includes discussion of gender differences in science participation and the importance of considering student attitudes. The application of Fishbein and Ajzen's Theory of Reasoned Action to the problem of student attitudes and prediction of science participation choices is reviewed and the importance of including self-efficacy and epistemological beliefs in the prediction of participation is discussed. The second paper is a report of a study of high school freshmen's attitudes and intended enrollment in physics, chemistry, and biology classes. A general conclusion follows the second paper.

References are included with the chapter in which they are cited. Material included in the appendices and references to that material will not be submitted to journals.

References

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179-211.

Ajzen, I., & Fishbein, M. (1980). Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Crawley, F.E., & Coe, A.S. (1990). Determinants of middle school students' intention to enroll in a high school science course: An application of the Theory of Reasoned Action. Journal of Research in Science Teaching, 27(5), 461-476.

Crawley, F.E., & Black, C.B. (1992). Causal modeling of secondary science students' intentions to enroll in physics. Journal of Research in Science Teaching, 29(6), 585-599.

Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, Mass.: Addison-Wesley.

Gardner, P.L. (1975). Attitudes to science: A review. Studies in Science Education, 2, 1-41.

Hill, O., Pettus, C., & Hedin, B. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. Journal of Research in Science Teaching, 27(4), 289-314.

Kahle, J.B., & Meece, J. (1994). Research on gender issues in the classroom. In D. L. Gabel, (Ed.), Handbook of Research in Science Teaching and Learning. (pp. 542-557). New York: MacMillan Publishing Co.

Koballa, T.R. (1988). The determinants of female junior high school students' intentions to enroll in elective physical science courses in high school: Testing the applicability of the Theory of Reasoned Action. Journal of Research in Science Teaching, 25(6), 479-492.

Mullis, I., & Jenkins, L. (1988). The science report card: Elements of risk and recovery. Princeton, NJ: Educational Testing Service.

Mullis, I.V.S., Dossey, J.A., Campbell, J.R., Gentile, C.A., O'Sullivan, C., & Latham, A.S. (1994). NAEP 1992 Trends in Academic Progress. (National Center for Education Statistics Report No. 23-TR01). Washington DC: US Government Printing Office.

National Science Foundation. (1988). Women and Minorities in Science and Engineering. (NSF 88-301). Washington, D.C.: Author.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. Review of Research in Education, 16, 153-222.

Oliver, J. S., & Simpson, R. (1988). Influences of attitude toward science, achievement motivation, and science self concept on achievement in science: A longitudinal study. Science Education, 72(2), 143-155.

Rosser, S.V. (1990). Female-Friendly Science. New York: Pergamon Press.

Schibeci, R. (1984). Attitudes to science: An update. Studies in Science Education, 11, 26-59.

Simpson, R.D., Koballa, T.R., Oliver, J.S., & Crawley, F.E. (1994). Research on the affective dimension of science learning. In D. L. Gabel, (Ed.), Handbook of Research in Science Teaching and Learning. (pp. 211-234). New York: MacMillan Publishing Co.

Simpson, R., & Oliver, J. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. Science Education, 74(1), 1-18.

United States Department of Education. (1993). Digest of Educational Statistics. (NCES 93-292). Washington, DC: Author.

Widnall, S.E. (1988). AAAS presidential lecture: Voices from the pipeline. Science, 241, 1740-1745.

RELATIONSHIPS OF GENDER, PERSONAL EPISTEMOLOGICAL BELIEFS, SCIENCE SELF-EFFICACY, ATTITUDE, AND SUBJECTIVE NORMS TO INTENDED SCIENCE CLASS ENROLLMENT: A REVIEW OF THE RELATED LITERATURE

A paper to be submitted to the Review of Educational Research

Charlotte Wieck Haselhuhn

Introduction

Women are underrepresented in science education and science careers. When the term "underrepresentation" is used in this review, it is not implied that men and women must enter science careers in proportions equal to their representation in the population. Rather, it is argued that the educational and social experiences of many girls and women in our culture discourage some, who would otherwise have been qualified for and interested in training for science careers, from entering such careers. In 1986, women constituted only 15% of all employed engineers, scientists, and mathematicians in the United States, although women made up 49% of the total professional workforce (Oakes, 1990). Women with degrees in science are less likely than men with science degrees to be employed in a scientific field, with 25% of women with science degrees employed in outside areas (Oakes, 1990).

Underrepresentation of women is not equal across all areas of science. In 1986, women made up 25% of people employed in the life sciences, but only 13% of those employed in the physical sciences (NSF, 1988). The gender difference is particularly large in engineering, with only 1.5% of the total number female (NSF, 1980, cited in Hill, Pettus, & Hedin, 1990).

Women are less likely than men to pursue college degrees in science. Widnall (1988) described a study that followed a cohort of 2000 male and 2000 female students from grade

9 through completion of their college careers. Among the males, 7% chose to enter scientific fields when they entered college, but only 2% of the females chose majors in any area of science. However, only 2% of the males and 1% of the females in the original cohort actually completed a bachelors degree in science. As is observed for careers in science, the proportion of women who obtain degrees in science differs with the specific field. During the 1989-1990 academic year, women obtained 50.8% of the bachelors degrees awarded in life science, but only 31.3% of bachelor degrees awarded in the physical sciences and 16.0% of the degrees awarded in physics (US Department of Education, 1993). Gender differences in participation are maintained through the level of the doctoral degree. In 1989-1990, women earned only 14.8%, 8.9%, 17.7%, and 19.4% of the doctorates awarded in the United States in computer science, engineering, mathematics, and physical science, respectively (US Department of Education, 1993).

Gender differences in science participation appear well before students enter college and choose careers. For most students in the United States, high school is the first opportunity to choose whether to take particular science courses and whether to continue in science beyond the required courses. On the average, girls complete half a semester less science in high school than do boys, and most of the difference occurs in the physical sciences (Bowyer, Linne, & Stage, 1980, cited in Koballa, 1988). The 1992 National Assessment of Educational Progress (NAEP) report (Mullis, Dossey, Campbell, Gentile, O'Sullivan, & Latham, 1994) indicated that physics is the area of high school science taken by the smallest proportion of students. Biology was studied by 92% of high school students, followed closely by general science. Chemistry was studied by 40% of high school students, with physics following at a distance: only 14% of 17-year-olds had taken (or were currently taking) physics in the 1992 NAEP sample. Although more girls than boys in the 1992 NAEP study took biology and chemistry in high school, fewer girls than boys took high school physics. Fifteen percent of boys in the 1992 sample had taken or were currently taking high school physics, but only 12% of the girls had taken or were taking physics. The gender gap in science course enrollment is largest in the area of physics. There was a significant increase in the proportion of girls enrolled in physics between 1986 and 1992, up from 8% in the 1986 sample. In Iowa, girls made up about 44% of high school physics classes during the 1993-1994 school year, although the proportion of physics classes made up by girls varied widely with individual districts. Among the 20 Iowa school districts with the largest physics class enrollments, the proportion of girls enrolled ranged from .15 to .56 (Voss, 1995, January 30).

Kahle and Lakes (1983) reported that girls at ages 13 and 17 were far less likely than boys to participate in extracurricular, non-required physical science activities. For example, girls of these ages were less likely than boys to have fixed something electrical or mechanical, although they were more likely than boys to have tried to understand an unhealthy plant or animal. Hill, Pettus, and Hedin (1990) reported that middle-school and high school girls participated less often than boys of the same age in science-related activities and hobbies outside school. Kahle and Lakes (1983) reported that gender differences in science participation occurred as early as age nine. Although girls of this age expressed as much interest as boys in participating in scientific experiences such as looking at the moon through a telescope or seeing an egg hatch, girls had fewer opportunities to participate in such activities. Consistent with gender differences in participation in different areas of science reported above, nine-year-old girls in the Kahle and Lakes study were more likely than boys to desire to take science field trips to sites such as a doctor's office or a TV station, but were less likely to indicate a desire to visit to an electric plant.

Concerns about the differential participation of males and females in science have originated from two perspectives: one based on a predicted shortage of qualified scientists and the other concerned with gender equity and equality issues (Kahle & Meece, 1994). Concerns were raised following predictions made by the National Science Foundation (NSF) in 1987 of a significant decline in the number of science bachelor's degrees awarded to students who were citizens of the United States, with a resulting drop in the number of science doctorates predicted (Rosser, 1990; Oakes, 1990). With a shortage of well-trained scientists in the United States by the mid 1990's and with demographic trends predicting fewer white males than before enrolling in college in the 1990's, science educators suggested that minority students and females would be required to fill the vacancies (Widnall, 1988).

The second perspective on differential participation of men and women in science concerns gender equity and equality issues. Concerns have been raised that girls and women do not have equal access to the economic opportunities afforded by entrance into science and engineering careers (Oakes, 1990). It has been suggested that stereotyping of science as a masculine profession, male-friendly science content and pedagogical approaches, and discrimination against women prevents females from entering science careers (Rosser, 1990).

Why are women underrepresented in the physical sciences? In a review of the literature on gender issues in math and science, Kahle and Meece (1994) discussed several factors that contribute to differential participation, including differences in cognitive abilities, sociocultural variables, home and family variables, educational variables, and student attitudes. Individual differences include possible gender differences in cognitive abilities. Some researchers have contended that there may be biological differences between the genders that affect learning in math and science (Benbow & Stanley, 1980). Gender differences in spatial abilities have been suggested by Lubinski and Benbow (1992) as a partial explanation for science participation differences among highly gifted students. Lubinski and Benbow reported gender differences, favoring males, in spatial and mechanical reasoning abilities among a sample of mathematically gifted seventh and eighth grade students. Strong spatial abilities are characteristic of physical scientists, and students self-select career areas based, in part, on such cognitive skills. However, Kahle and Meece (1994) cited a recent meta-analysis by Linn and Peterson (1985) to support their contention that gender differences in spatial abilities are minimal and primarily limited to orientation and mental rotation tasks, and that gender differences are minimized further by instructional interventions.

Sociocultural variables that have been investigated include gender stereotyping of careers and areas of study, parent attitudes toward achievement and gender-appropriate activities, expectations of teachers, and influence of peers. Science is perceived by many as a male domain. This stereotype discourages girls from entering science careers (Kahle & Meece, 1994). The degree of male stereotyping depends on the specific science area, however. Drawing from Kahle's earlier work, Kahle and Meece (1994) provided evidence that engineering, physics, and chemistry were among the sciences considered masculine by college students; microbiology, physiology, and botany were considered neutral; and social sciences were considered feminine.

Adult influence on science participation and achievement of boys and girls reflects sociocultural stereotypes. Boys may be provided with more opportunities than girls to engage in science activities at home (Kahle & Lakes, 1983). Parents encourage their sons more than their daughters to take advanced math, chemistry, and physics (Parsons, Adler, & Kaczala, 1982). In a survey of more than 4500 middle school and high school students, Simpson and Oliver (1990) found that parent attitudes toward science in general, as rated by students, were moderately correlated with student attitudes toward science. Teachers may have different expectations for success of boys and girls in math and science, and create school experiences that are different for boys and girls, so that girls have different expectations for success (Sadker, Sadker, & Klein, 1991).

Achievement in science may be related to decisions about science participation. Oakes (1990) suggested three interrelated factors that are critical to attainment in science: 1) the opportunity to learn science and mathematics 2) achievement in science and mathematics and 3) the decision to pursue education and careers in science and mathematics. Females, in comparison to males, lose ground in all three factors during their academic years. Kahle and Meece (1994), citing the results of the Second IEA Science Study (International Association for the Evaluation of Educational Achievement [IEA], 1988), indicated that boys achieve better than girls in biology, chemistry, and physics in grades 5 through 12 in the United States. The largest differences in science achievement are in the areas of physics, chemistry, earth science, and space science (Mullis and Jenkins, 1988). High school science achievement of students is a strong predictor of selection and completion of a science major in college (Oakes, 1990). Lower achievement may limit girls' opportunities to take advanced courses or girls may choose not to enroll in advanced science courses. Students who take fewer science courses in high school are less prepared for science majors in college.

Student attitudes toward science may also have a significant influence on choices about science participation. Simpson and Oliver (1990), in their report of a longitudinal study of 4500 middle school and high school students, concluded that attitude at grade 10 predicted future course-taking in science. Students with less positive attitudes toward science did not tend to pursue additional courses in science. However, attitude toward science at grade 10 did not distinguish between students who took advanced science courses as general college preparation and those who took more advanced science courses as preparation for a science major in college.

Gender differences in attitude toward science are observed as early as elementary school. Most young children are curious about the natural world (Peltz, 1990) but gender differences in science interests appear in elementary school. Among 9-year-olds, girls generally express as much interest in science in general, and as much positive affect toward science as do boys. Specific science interests may differ for boys and girls of this age, however. As noted above, Kahle and Lakes (1983) found that girls were less likely to indicate interest in visiting an electric plant than were boys. By age 11, just before the middle school years, the science attitudes and interests shown by boys and girls are clearly different . Girls report less interest in science activities and careers, and participate less often than boys of the same age in science-related activities and hobbies outside of school (Hill, Pettus, and Hedin, 1990). Middle school girls also report less positive attitudes than boys toward science (Mullis & Jenkins, 1988).

Gender differences in attitude are maintained through high school. Of the students in the US who choose not to take a science class as a high school senior, 35% of the girls, but only 22% of the boys, indicated that the reason was that they did not like science. Attitude may also play a role in selection of college majors. Archer and Freedman (1989) found that 16- to 20-year-old British college students rated engineering, chemistry, physics, and math as more masculine than feminine. Kahle and Meece (1994) noted that college and university enrollment data indicates that some courses, such as microbiology, zoology, and botany are gender-neutral, but liberal arts and social sciences are predominantly feminine, and engineering, physics, and mathematics are predominantly masculine.

Although there seems an obvious link between one's attitude toward science and participation in science activities, and hundreds of investigations have centered on the relationship between attitudes, participation, and achievement in science (see Gardner, 1975; Schibeci, 1984; and Simpson, Koballa, Oliver, & Crawley, 1994 for reviews), the link has not always been strongly supported by empirical findings. Gardner (1975), in a review of the literature, found little support for a strong attitude-achievement relationship. Schibeci (1984), in a more recent review, reported correlations ranging between 0.07 and 0.84 between science attitude and science achievement, with most correlations positive but small.

Attitude toward Science and Science Participation

An attitude is "a predisposition to respond positively or negatively to things, people, places, events, or ideas" (Simpson et al. 1994, p. 212). It is important to distinguish between "attitude toward science" and "scientific attitudes." Scientific attitudes are ways of thinking that are considered important to the pursuit of science, such as open-mindedness, honesty, and skepticism (Gauld & Hukins, 1980). Attitude toward science is a response concerning some object in the field of science. For instance, a person might show a like or dislike toward science classes, or science careers, or the field of science in general. Interest in science, motivation to achieve in science classes, or beliefs about one's abilities in science could be considered components of attitude toward science. The focus of this paper is on attitudes toward science, as opposed to scientific attitudes.

Gender Differences in Attitude toward Science

Although there is general agreement that gender is one of the most important variables related to attitudes toward science, results of studies investigating gender differences in attitude toward science have been inconsistent (Schibeci, 1984). Several studies have reported that males have more positive attitudes toward science than females. Girls begin school expressing as positive an attitude toward science as boys, but by high school more boys than girls indicate that they like science (American Association of University Women [AAUW], 1990). A gender difference in liking of science has been reported even among gifted populations. Gifted boys showed a significantly higher preference than gifted girls for math and science fields in a study of high school students conducted by Feldhusen and Willard-Holt (1993).

Although Schibeci (1984, p.33) asserted that gender had generally been shown to be a consistent influence on science attitudes, consistent gender differences in attitude have not been found. Schibeci cited several articles that reported only some gender differences or no gender differences in attitudes. One possible reason for inconsistency of results in this area is inconsistency in the definition of "attitude toward science" and in the measures of attitude used in research. Among the constructs considered as attitudes toward science are interest, liking, self-confidence, self-concept, anxiety, achievement motivation, and career aspirations. The objects of attitudes measured have included science classes, science teachers, the usefulness of science, and perceptions of being a scientist.

Part of the reason for the apparently inconsistent results is a failure to distinguish between the physical and biological sciences. In a three-year longitudinal study that followed 1300 eleven-year-old boys and girls, Kelly (1986) found that girls' attitudes toward physical science were less positive than those of boys, but that girls were more interested than boys in nature and human biology. Haselhuhn, Andre, Whigham, and Veldhuis (1995) also found that although middle-school age girls indicated more positive attitudes than boys toward biological science, boys were more positive than girls toward physical science.

Age and Attitude toward Science

There is general agreement among studies that students' positive attitudes toward science decline with age (Schibeci, 1984). In a longitudinal study, Simpson and Oliver (1990) found that interest and liking of science declined for both males and females from grades 6 through 10. Not only did student attitudes decline with increasing grade levels, attitudes declined within each school year. Except at grade 9, attitude toward science was more positive at the beginning of the year than at the end.

Lawrenz (1987) reported no gender differences in reported satisfaction with science classes or perceived difficulty of the class among 149 fourth-grade students and 184 seventh-grade students in Arizona. But at the high school level, in a sample consisting of 58 students from six schools in Arizona, boys and girls differed in their ratings of satisfaction with science classes, though the gender of the student interacted with teacher gender. Girls with male teachers showed more favorable attitudes, and boys with female teachers showed more positive attitudes than did other students.

Decline in attitudes toward academic subjects may be specific to science, and may even depend on the specific area within science. In a cross-cultural study involving 2105 adolescent girls in British Colombia and China, Collis and Williams (1987) reported a decline in attitudes toward science from grades 8 to 12, but reported that girls showed an improvement in attitude toward writing across the same time period. Kelly (1986) also found that student attitudes toward science decreased with age. In a sample of students assessed at age 11 and again at age 14, the attitudes of girls dropped more than that of boys. However, the decline in interest and attitude differed depending on the specific area of science. Student interest in human biology increased between age 11 and age 14 for both boys and girls, with the largest increase found for girls. Student attitudes in other areas of science, such as physical science and nature studies decreased for both boys and girls, although the decrease in interest was greater for girls. Haselhuhn et al. (1995) also demonstrated that age differences in attitude toward science may differ with the particular area of science. In their cross-sectional study of 550 Iowa middle school students, attitudes toward physical science were similar for students in grades 5 or 6 and those in grades 7 through 9. Attitude toward biological science was more positive for older students than for younger students, with larger attitude differences for females than males.

Relationship between Attitude and Achievement in Science

Studies investigating the relationship between attitude and achievement in science have most often reported small positive correlations. Levin, Sabar, and Libman (1991) measured several areas of science attitude, including the perceived importance of science, interest in science as a profession, perception of science instruction, difficulty of science in general and comparison of science achievement to other areas of study. Science achievement was measured by a test constructed to assess knowledge, comprehension, and application in biology, earth science, chemistry, and physics. In their study of almost 2000 9th grade students in Israel, attitude accounted for about 20% of the variance in achievement for males and about 10% for females. Science self-image, defined as students' perceptions of their ability to perform well in science, was the best predictor of science achievement for both boys and girls. Perceived difficulty of science learning was also a significant predictor of achievement for boys and girls. Napier and Riley (1985) found that the degree to which students engaged in science-related activities outside the classroom, degree of teacher-direction in the classroom, anxiety about science, and the degree of teacher support predicted 16% of the variance in science achievement for 17-year-olds. Science self-concept, defined as the extent to which science made the student feel smart, confident, successful, and happy, showed a small but significant correlation with achievement. Oliver and Simpson (1988), in their study involving middle school and high school students, found that variables such as attitude toward science, achievement motivation, and science self-concept accounted for nearly 20% of the variance in science achievement. In general, science self-concept was a better predictor of achievement than was science attitude.

The variability in correlations found between science attitude and achievement should not be surprising. As Schibeci (1984) noted, attitude research in this area is often technically poor. In research in attitudes and science education, attitude has been loosely defined, and often more than one construct is often included in a single measure. The scales used to measure attitude have often been poorly constructed, and their validity characteristics poorly described. Studies of change in attitudes have more often been cross-sectional than longitudinal, so that it is not possible to examine the stability of attitudes in individuals. The finding of weak and variable relationships between attitude and behavior is not unique to the field of science education, however. Fiske and Taylor (1991) pointed out that inconsistent relationships between attitude and behavior have long been a problem in social psychology.

Methodological and measurement problems in studies of the relationship between science attitudes, achievement, and participation may explain some of the variability in correlations obtained. There is no universally agreed-upon definition of attitude (Olson & Zanna, 1993) and the use of multiple measures based on different definitions contributes to the inconsistency in results when researchers attempt to relate science attitudes to science behaviors. As Schibeci (1984) noted, science attitude has been defined variously as attitude toward science instruction, toward laboratory work, or toward technology. Differing constructs such as science self-concept (Napier & Riley, 1985), importance of science (Levin et al., 1991), motivation to achieve in science, science anxiety, attitude toward the science teacher, attitude toward science curriculum, and enjoyment of science (Simpson and Oliver, 1990) have all been defined as attitude toward science.

An attitude is a hypothetical construct; it can not be observed but must be inferred from an individual's responses to stimuli (Fiske & Taylor, 1991). Attitude is assumed to act as an intervening link between an observable stimulus and an observable behavior, and is often defined as a predisposition to respond in a particular way toward an object (Simpson et al., 1994). An attitude object may be a person or group of people, a place, event, or idea. The concept of attitude is often divided into three components: affect, cognition, and behavior (Fiske & Taylor, 1991). Affective responses consist of feelings toward the attitude object, and cognitive responses result from information and perceptions about the attitude object. The behavior component may include both behaviors toward the object and the intention of behavior toward the attitude object. Fiske and Taylor pointed out that the three components may not always be consistent and that some social psychologists have dealt with the inconsistency of the three components by suggesting that attitudes are based on cognitive, affective, and behavioral information.

Some behaviors and some situations are more prototypical of particular attitudes than others. For instance, an advanced physics course may be considered a better prototype of a "science class" than is a freshman health class. The relationship between the attitude of "liking science" and the behavior of signing up for a science course is more likely to be evident when the student is faced with the prototypical situation. Signing up for a physics course would have a greater relationship with "liking science" than would signing up for a health course.

Fiske and Taylor (1991) argued that attitudes and behaviors often correlate poorly because they have been measured at different levels of specificity. Ajzen and Fishbein (1980) distinguished between prediction of single actions and prediction of behavioral categories. A behavioral category is a set of actions. They claimed that, although general behavior categories may be predicted from broad measures of attitude, predictions of specific behaviors are not accurately predicted by broad attitude measures. A student's choice to enroll in a particular science course is a highly specific behavior, and according to Ajzen and Fishbein, accurate prediction of enrollment in specific science courses by general science attitude measures would not be expected. To predict enrollment in a high school physics course, the attitude of the student toward the specific behavior of enrollment in that particular physics course must be measured. In order to predict specific behaviors, the attitude and the behavior must be matched in terms of action, target, context, time.

Fishbein and Ajzen's Theory of Reasoned Action

Fishbein and Ajzen (1975) proposed a theory in which the cognitive and affective aspects of an attitude interact to influence behavioral intentions, and through behavioral intentions, behavior. Fishbein and Ajzen's Theory of Reasoned Action (1975; Ajzen & Fishbein, 1980) stated that behavioral intentions, which predict behaviors, are a function of a person's attitude toward a behavior, the extent to which the person perceives that there is support from others for engaging in the behavior (the subjective norms component), and a set of weights that represent the relative contribution of each factor.

Figure 1 illustrates the components of the behavior of enrolling in a high school physics class, according to the Ajzen and Fishbein (1980) model. The behavior of interest, enrollment in a high school physics class, is predicted best by the reported intention to enroll in such a class. Intention, in turn, is predicted by some combination of a student's attitude toward enrollment in a high school physics class and his or her perception of the expectations of other individuals or groups. A student's attitude toward enrollment in a high school physics class is composed of two types of beliefs. A student will expect certain outcomes to occur if he or she enrolls in such a class and will evaluate each outcome as positive or negative. The subjective norm component is also made up of two types of beliefs: students' beliefs about whether family, teachers, friends or others want them to enroll in a physics class and the extent to which they want to comply with such wishes. External variables that may be relevant to enrollment in high school physics classes include gender, science ability, science self-efficacy, and personal epistemological beliefs.

In the Theory of Reasoned Action, the behavior that is predicted must be specified in terms of action, target, context, and time. The specific behavior follows the closely related behavioral intention or the commitment to engage in the behavior. Three conditions must be met for performance of a behavior to be accurately predicted by intentions. First, measurement of intentions and perceptions of control must be specific to the behavior of interest. The context specified when measuring intention and control must be the same as

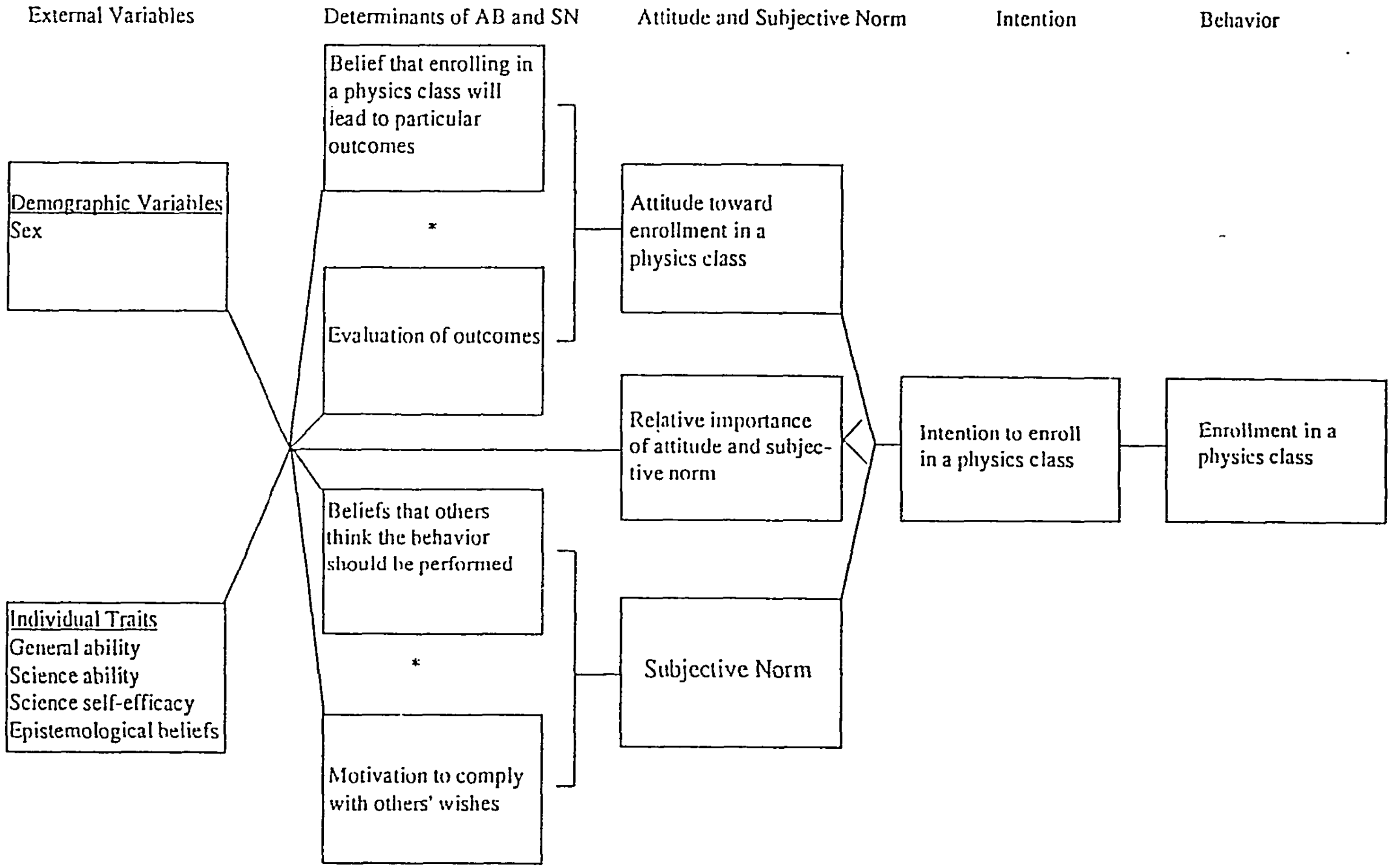

Figure 1. Relations among External Variables, Beliefs, Attitudes, Subjective Norm, Intention and Behavior according to Fishbein and Ajzen's Theory of Reasoned Action

that in which the behavior occurs. Second, intentions and behavioral control must remain consistent between the time they are measured and the time the behavior will occur. Intervening events that change intentions or perceived control will reduce the accuracy of prediction. Third, behavior must be under the volitional control of the individual. If the behavior is under volitional control of the individual, the stronger the intention, the more likely it is that the behavior will occur.

In the Theory of Reasoned Action, two components contribute to behavioral intention. The affective component of the model is termed "attitude toward behavior" or "AB." Attitude toward behavior has a direct effect on behavioral intention (BI), the behavioral component of the model. A second component that precedes behavioral intention in the Theory of Reasoned Action is a normative factor. Subjective norm (SN) is a person's perception of support from important others for engaging in the specific behavior.

Each of the two components that influence behavioral intention is made up of beliefs about the specific behavior. One component of attitude toward behavior is one's personal beliefs (b) about the outcomes that would occur if one engaged in the behavior. Each expected outcome of the behavior is associated with an evaluation of the outcome (e). Any particular outcome has a specific likelihood of occurrence, and an evaluation of whether that outcome is considered positive or negative. The sum of the products of individual outcome beliefs and the expectation that the specific outcome would occur gives an estimate of the attitude toward behavior. Attitude toward behavior (AB) is thus expressed with the following equation: $AB = \Sigma(b)(e)$. Attitude toward behavior may be measured directly by asking for ratings of attitude toward performance of the behavior or may be measured indirectly by measuring salient beliefs and their respective evaluative component.

For instance, if a researcher were interested in personal beliefs about enrollment in a high school physics class, a direct measure would consist of asking a student to rate the extent to which taking a physics class is favorable or unfavorable. Alternatively, the researcher could indirectly measure the attitude by collecting ratings about student beliefs about the likely outcomes of taking a high school physics class and multiplying each outcome belief by the student rating of the evaluation of the outcome. A student might be asked to indicate whether taking a physics class would result in a decrease of grade point average and in a companion item, to indicate whether a decrease in grade point average is considered good or bad.

The subjective norm component is also made up of two subcomponents, beliefs and a weight factor. Normative beliefs about the extent to which other individuals or groups support the behavior (nb) and the person's motivation to comply with specific others (mc) combine to determine the subjective norm. Summing the products of each normative belief multiplied by its individual motivation to comply rating gives an estimate of the subjective norm component. The subjective norm (SN) component may thus be expressed as: $SN=\Sigma(nb)(mc)$. The subjective norm component may be also be measured directly by asking the respondent to indicate to what extent others wish him or her to engage in the behavior.

The Theory of Reasoned Action is represented by the following:

$$B = BI = w_1\Sigma(b)(e) + w_2\Sigma(nb)(mc)$$

or,

$$B = BI = w_1AB + w_2SN$$

where B is the behavior, BI is the intention to perform the behavior, and w_1 and w_2 are the relative contributions of attitude toward behavior (AB) and subjective norms (SN), respectively.

Weights w_1 and w_2 may change depending on the specific behavior that is predicted and are an empirical matter. According to Ajzen (1991) the more positive the attitude and the subjective norm, the stronger the behavioral intention and the greater the likelihood that the behavior will occur. But the relative importance of each component will vary across different behaviors and situations. Any variation in action, target, context, or time may change the relative influence of attitude and subjective norm. Ajzen and Fishbein (1980) noted that attitudinal components may be more important than the subjective norm for determining competitive behavior, though cooperative behaviors are more closely related to the subjective norm component. van den Putte (1993) conducted a meta-analysis of 113 studies applying the Theory of Reasoned Action. He concluded that behaviors with personal relevance, such as studying, were largely influenced by attitude, but that recreational behaviors such as alcohol use were largely under subjective norm control.

Because the Theory of Reasoned Action postulates that AB and SN may interact, the following model has also been used to study the relationship between attitudes and behavior in science (Crawley, 1990): $B = BI = w_1AB + w_2SN + w_3(AB*SN)$.

According to the model proposed by Ajzen and Fishbein (1980), variables such as gender, race, ability, interest, or self-concept do not directly affect the intention to engage in a behavior. Such demographic variables and personality traits are considered external variables that may influence behavioral intentions and behaviors only through their influence on attitude toward behavior or subjective norm. External variables act by affecting the determinants, or underlying beliefs, of attitude toward behavior or subjective norm or by influencing the relative importance of these two components of behavioral intention.

Application of the Theory of Reasoned Action to Science Attitudes and Behaviors

Fishbein and Ajzen's (1975) model has been applied to research in science attitudes and behavior. The behavior of enrolling in science classes is one that can be defined at a high level of specificity in terms of action, target, context, and time. Use of the model has allowed investigation of the importance of outcome beliefs and influence of others in course enrollment decisions.

Using a sample of 100 middle-school students in central Texas, Crawley and Coe (1990) applied the Theory of Reasoned Action to the prediction of students' intentions to enroll in high school science courses. They developed measures of attitude toward behavior and subjective norm according to guidelines specified by Ajzen and Fishbein (1980). Their final questionnaire consisted of questions concerning intention, attitude toward enrollment, subjective norms, and personal belief statements and normative belief statements. Students' personal beliefs about the impact of taking a high school science course on learning new information, preparing for college, learning to do experiments, and meeting new students were measured. Individuals and groups considered in the subjective norms beliefs items included family members, college admissions officers, counselors, close friends, and teachers. The intended behavior measured by Crawley and Coe was enrollment in a high school science class, assuming that enrollment was optional. A limitation of this study is that students could not rate their actual intention to enroll in a science class their freshman year; science enrollment was required of all students. Crawley and Coe asked students to indicate what their enrollment intentions would have been if enrollment had been optional.

Crawley and Coe (1990) found that attitude toward enrollment and subjective norms predicted intended science class enrollment. Sex, ethnicity, general ability, and science ability did not predict enrollment after the effects of attitude and subjective norm were removed, although the correlation between science ability and intended enrollment was significant. The relative effects of attitude and subjective norm differed depending on the student's gender. Attitude toward enrollment was the only predictor of intent for male students. For female students however, subjective norm was the best predictor, though attitude also made a significant contribution. Thus, among students in Crawley and Coe's middle school sample, the opinions of other people or groups were important determinants of intended science course enrollment for females, but not for male students.

Koballa (1988) applied the Theory of Reasoned Action to the study of science attitudes and behavior. In a sample of 94 Texas middle-school students, Koballa investigated the relationship between girls' attitudes toward enrollment in physical science courses, their perception of subjective norms concerning enrollment, and their intentions to enroll in a physical science course in high school. He also assessed external variables often evaluated by science educators when trying to predict science participation: ability grouping, science grades, and general attitude toward science. Although it is not clear from Koballa's report, he apparently defined ability grouping as whether the student attended a science class designed for average students or a class designed for low-ability students. Koballa used the guidelines recommended Ajzen and Fishbein (1980) to develop the scales of the separate components of attitude and of subjective norms. He first asked a sample of female students to generate lists of positive or negative outcomes of enrolling in physical science electives and lists of people or groups of people who could have expectations about the student's enrollment in physical science courses. The responses were sorted into categories, 13 for the enrollment belief statements, and 9 for the subjective norm statements. These student-generated categories were used to create the final scales. Koballa hypothesized that the external variables, including science grades, ability group, and general science attitude, would not predict physical science enrollment directly. Any influence on science enrollment should occur through the effects of these external variables on attitude toward science enrollment or subjective norms. None of the external variables were correlated with intent to enroll in physical science classes, although science grades and science attitudes approached significance. None of the external variables were correlated with attitude toward enrollment in physical science courses or with subjective norms. However, attitude toward course enrollment and social support for enrollment were significant predictors of female students' enrollment intentions, with attitude the best single predictor.

Crawley (1990) applied the Theory of Planned Behavior (Ajzen, 1991) in an investigation of the determinants of science teachers' intentions to use a particular teaching method. The Theory of Planned Behavior is an extension of Ajzen and Fishbein's Theory of Reasoned Action. Ajzen's theory adds a third component of behavioral intention, called perceived behavioral control. It is a useful addition to the model in situations in which a person may not have complete control over the performance of a behavior. Crawley used the Theory of Planned Behavior in the prediction of the intention of 50 science teachers enrolled in a Texas inservice institute to use newly learned activities in their classrooms. Attitude toward performance of the behavior was the best predictor of behavioral intent in the Crawley study, though subjective norm also made a significant contribution. When perceived behavioral control was added to the analysis, only a nonsignificant 4% of additional variance was explained. However, when perceived behavioral control was treated as an external variable, Crawley found that attitude toward behavior and subjective norm components predicted differently for teachers high or low on perceived behavioral control. Only attitude was a significant predictor for teachers with low behavioral control scores, but both attitude and subjective norms predicted intention among teachers with high behavioral control scores. Age and gender indirectly influenced behavioral intention. Attitude and subjective norms predicted intention for females and for teachers under 34 years of age, but neither predicted significantly for males or for teachers over 34 years. Although perceived behavioral control did not appear to have direct effects on behavioral intention in this study, this result may have been obtained because of the restricted range in the estimated amount of behavioral control among members of the group. Most of the teachers indicated that they perceived a high degree of behavioral control.

The studies discussed above suggest that the Theory of Reasoned Action is useful for the investigation of course enrollment decisions among middle and high school students. However, in a report of a recent meta-analysis including 113 studies applying the Fishbein and Ajzen model, van den Putte (1993) concluded that the model was not as useful for persons under age 20 as it was for older populations. When predicting such behaviors as smoking, drug use, studying, or use of contraceptives, attitude and subjective norm components predicted between 43% and 66% of the variance in intent for older groups, but only 35% of the variance in intent for younger groups. Among studies that have applied the Theory of Reasoned Action to science course enrollment decisions, attitude and subjective norm components have predicted from 35% (Crawley & Coe, 1990) to 40% (Koballa, 1988) of the variance in intent. Although investigation of student attitudes and the influence of others with the Fishbein and Ajzen model may provide useful information, over half the variance in enrollment decisions is left unexplained by the basic, three-predictor model.

Variables Related to Enrollment Choice and Persistence

Self-efficacy and Learning

Self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Self-efficacy beliefs are made up of two components. The first component is the belief in one's capability to perform a task. The second component is one's expectations about the outcomes of performing the task (Tobin, Tippins, & Gallard, 1994), or the perceived value of the task. Tobin et al. noted that the perception of capability is a more important factor in behavior than is perceived value of a task.

Perceived self-efficacy can affect choice of activities and the extent to which a person chooses to persist in an activity. People with low self-efficacy beliefs about success in a particular behavior are likely to avoid the task. If they must perform the task, they are likely to expend less effort and persistence. People with high self-efficacy concerning a particular behavior are more likely to choose to participate and will work harder and longer at the task.

Self-efficacy beliefs are formed from information gained in one's previous performance of a behavior, observations of the performance of others, persuasive messages, and one's feelings of anxiety or comfort (Schunk, 1989). In general, prior success in a task increases self-efficacy and failure lowers self-efficacy. However, the effects of success or failure on self-efficacy and subsequent task choice and persistence may be mediated by attributions for the success or failure. Observation of similar others performing a task provide self-efficacy information. For instance, if a peer has enrolled in high school physics and completed the course successfully, a student may acquire a higher sense of self-efficacy for enrollment and performance in physics and is more likely to enroll in the course in the future. Persuasive messages are considered less effective than other influences on self-efficacy, and the effects are relatively short-lived (Schunk, 1989).

Gender differences in self-efficacy. Tippins (1991) developed a self-efficacy scale for high school students that is specific to the domain of science. Students were asked to rate their confidence in their ability to perform tasks, problems, and coursework in science. In a sample of 817 Texas ninth-graders, males showed slightly higher science self-efficacy than did females. Science self-efficacy scores predicted intended high school science course enrollment. The direction of the correlation was unexpected, however. Tippins reported that for her sample, the greater the science self-efficacy score, the lower the intention to take additional science courses. This result is suspect, because Tippins reported that boys show higher science self-efficacy than girls and are more likely than girls to indicate that they intend to enroll in future science classes. It should also be noted that Tippins' sample included a number of high schools that were not predominantly White. There is evidence that the self-efficacy of Black girls is generally higher than that of White girls, even though Black students show lower rates of participation in science beyond that required (Oakes, 1990).

Eccles, Barber, Updegraff, and O'Brien (1995) investigated gender differences in 695 high school students' self-concepts of ability in physical science, their ratings of utility of physical science, and the relationships of self-concept and utility to the number of physical science courses taken. Gender correlated .25 with self-concept of ability and .13 with perceived utility of physical science, with males indicating higher self-concept and greater perceived utility. Neither self-concept of ability nor perceived utility mediated the effects of gender on enrollment in physical science courses, however.

Gender differences in model similarity, attributions for success and failure, and performance feedback given by teachers may result in differing levels of self-efficacy in physical science for boys and girls. The more similar a model is to the student, the more likely the student is use the model's performance as a self-efficacy cue. Gender is one important area of similarity. The majority of physics teachers are male, and the majority of the high school students who participate in physics are male, so that females have few gender-similar models. Nationally, only 31.7% of secondary chemistry and physics teachers are women (NSF, 1992). In Iowa, women make up only 30% of high school math and science teachers, and only 15% of Iowa's physics teachers are women (Voss, 1995, January 29).

Sexism in science textbooks is another area in which gender differences in model similarity are found. Rosser (1990) noted that although blatant sexism in textbooks has been eliminated in the last two decades, subtle forms of sexism remain. Women may be present in science text illustrations but not included in text. Contributions of women scientists are still omitted frequently. Topics of particular interest to females, such as childbirth or menopause, are often left out of science texts.

Eccles (1985) discussed the role of gender stereotypes in girls' expectations for success at difficult academic activities. Because girls may be stereotyped as less competent than boys, girls have lower expectations for success, and expect to have to work harder to achieve success. This is especially true in fields that are highly gender-stereotyped, such as science and math.

Gender differences in self-efficacy in science may be due to differing patterns of attributions for success and failure in science. Weiner (1985) categorized attributions as stable/unstable and internal/external. Ability and effort are both internal attributions, but ability is stable and effort is unstable. Task difficulty and luck are external attributions, but task difficulty is stable and luck is unstable. Girls are more likely to attribute their successes to effort and their failures to ability, a pattern of attribution that leads to low self-efficacy for learning difficult new cognitive tasks (Eccles, 1985). Boys show an attributional pattern that is associated with high self-efficacy: attribution of success to ability, and attribution of failure to luck or effort. Of particular importance to this discussion is the gender difference in attribution of failure. Girls are more likely to attribute failure to a lack of ability. Ability, in Weiner's model, is a stable factor. A student who thinks that he or she has failed because of a lack of ability will not be motivated to put forth more effort, for no amount of effort will result in success. An attribution of failure to lack of effort may be motivating, however. Effort is a factor that is under the control of the student, and if a person has adequate ability, increased effort will lead to success.

Girls' attributions of success to effort, as opposed to ability, may also have a deleterious effect on later motivation to seek and persist in difficult tasks. An attribution to effort leaves future success on extremely difficult tasks in doubt.

Messages given to students about their successes and failures from parents and teachers may contribute to gender differences in attribution to ability. Sadker, Sadker, and Klein (1991) discussed the differential feedback given to boys and girls in the classroom: Boys who fail at a task are often told to work harder, but females are often told the answer. A possible implication from such a message is that a boy has the ability to succeed in science, if he only expends adequate effort, but a girl does not have the ability to succeed. Parents, too, may give differing messages about attributions to ability for boys and girls. Parsons, Adler, and Kaczala (1982) found that parents were more likely to attribute a girl's good math score to effort than to ability. Parents of boys who showed high math scores were less likely to make an attribution to effort. Children who learn to attribute success to effort are likely to have lower confidence in their ability to succeed in difficult tasks in the future. The message given to girls is that they are somehow less capable of learning the new task.

In a sample of 1654 students in grades 4 through 12, Ryckman and Peckham (1987) found that girls who had ability equal to that of boys, showed less advantageous patterns than boys of attribution in math and science. In math and science, girls were more likely to attribute success than failure to effort, but were more likely to attribute a failure to lack of ability. The attribution pattern for girls in the language arts area was different from that in math and science, however. In language arts, girls considered the effect of effort about equal for success and failure, and tended to attribute success to ability. Boys, in general, were less likely than girls to attribute performance to effort and were more likely than girls to attribute performance to ability.

Self-efficacy predicts course enrollment and persistence in science and engineering fields for college students. Lent, Brown, and Larkin (1984; 1987) found that self-efficacy in science and engineering predicted achievement in future science and technical course one year later and also predicted persistence in the field of science or technology. Self-efficacy added predictive variance beyond the variance accounted for by ability.

Lent, Larkin, and Brown (1989) measured science-related self-efficacy and engineering self-efficacy in undergraduates already enrolled in the college of technology or pre-engineering. Although they found no gender differences in self-efficacy for this group, gender differences in self-efficacy would probably not be expected in a group that has already persisted in the field science or engineering. Self-efficacy in science and engineering were moderately correlated with students' interest in science and engineering fields as measured by the Strong-Campbell Interest Scales. Lent et al. noted that interests are usually a stronger factor than self-efficacy in career choice, but self-efficacy is a stronger predictor of success and persistence in a chosen option. It is possible that interest would be more strongly predictive of course enrollment than would self-efficacy, which would predict how hard the student would work once enrolled in the course.

Self-efficacy and interests are probably highly related, however. Bandura (1982) suggested that self-efficacy is related to interests. Positive self-efficacy is related to development of interests in an area, and people remain interested in activities that create feelings of self-efficacy and satisfaction. So, a person's success or failure in initial encounters with a field or task will lead to feelings of self-efficacy that will influence future decisions about whether to engage in the same or similar tasks. A person will choose to engage in behaviors for which he or she has a sense of self-efficacy, leading to more opportunity for success and further enhancement of self-efficacy in that area.

Personal Epistemological Beliefs and Learning

Epistemological beliefs are related to persistence in academic tasks (Schommer, 1994). Epistemological beliefs are an individual's beliefs about the "source, certainty, and organization of knowledge, as well as the control and speed of learning " (Schommer, 1994, p. 293). When researchers are interested in the relationship between epistemological beliefs and learning, they generally move away from the traditional philosophical definitions. Instead, wrote Schommer, "cognitive researchers focus on what individuals believe about the degree to which information is true, the organization of information, the acquisition of knowledge, and the justification of knowledge claims" (p. 294).

In science, researchers have sometimes defined personal epistemological beliefs as unidimensional. Examples include a belief that learning must be quick, or the extent to which knowledge is a series of unrelated facts or a unified body of information (Songer & Linn, 1991). More elaborate models have been developed by researchers concerned with the nature of intellectual growth, such as Perry (1986, cited in Schommer, 1994) and Kitchener and King (1981). Both outline a series of stages of epistemological beliefs beginning with the belief that knowledge is absolute and handed down by authority and ending with the belief that knowledge is an ongoing process of inquiry.

Schommer (1994) argued that beliefs other than the certainty and source of knowledge should be considered by researchers in epistemological beliefs. She offered a model of personal epistemological beliefs that focused upon the relationships between such beliefs and learning. Schommer presented a multi-dimensional model, stating that personal epistemology is complex and that unidimensional models mask the relationship between personal epistemology and aspects of learning. According to Schommer, epistemological beliefs are a system of independent beliefs. She hypothesized five dimensions of personal epistemological beliefs (Schommer, 1994, p. 301):

"1. Source of knowledge: (varying) from knowledge is handed down by omniscient authority to knowledge is reasoned out through objective and subjective means.

2. Certainty of knowledge: (varying) from knowledge is absolute to knowledge is constantly evolving.

3. Organization of knowledge: (varying) from knowledge is compartmentalized to knowledge is highly integrated and interwoven.

4. Control of learning: (varying) from ability to learn is genetically predetermined to ability to learn is acquired through experience.
5. Speed of learning: (Varying) From learning is quick or not-at-all to learning is a gradual process."

Each dimension of epistemological beliefs was considered a continuum in the original model, although Schommer (1994) more recently suggested that people actually show a distribution of beliefs along each dimension. Schommer (1990) developed a scale to measure the five epistemological belief dimensions and used factor analytic methods to evaluate its validity with college-age students (Schommer, Crause & Rhodes, 1992). Schommer (1993) later conducted a confirmatory factor analysis with a high school sample. The same four factors, corresponding to four of the five hypothesized dimensions, were evident in both studies. As described from the naive perspective, the four factors are: 1) simple knowledge, 2) certain knowledge, 3) quick learning, and 4) fixed ability.

<u>Gender differences in epistemological beliefs</u>. High school girls may differ from high school boys in their beliefs on at least two dimensions. Schommer (1993) found that high school girls were less likely than boys to believe in fixed ability or in quick learning.

Support for gender differences in epistemological beliefs, as conceptualized by Schommer (1994), is found in the anecdotal reports of Rosser (1990). Many female scientists, according to Rosser, approach their work differently from most male scientists. Women in science may be less likely to believe that knowledge should come quickly or not at all. Women are inclined to take more observations and different kinds of observations than men before formulating a hypothesis. Women scientists are less likely to see knowledge as simple and discrete. Women involved in research are more likely than men to be concerned about the social implications of their work. They are also more likely to take on more holistic, global problems than the reduced and limited problems considered traditionally. Likewise, women may use methods from a variety of fields in solving a problem.

Gender differences in attributions to effort are consistent with gender differences in belief in quick learning and innate ability when successful experiences are considered. Girls, who are more likely than boys to believe that learning comes with time and effort, are also more likely than boys to attribute their successes to effort. But in failure situations, the consistency between belief in quick learning and attribution to effort or ability breaks down. In failure situations, girls are more likely than boys to believe that their poor performance was due to a lack of ability.

Age and personal epistemological beliefs. Many researchers have assumed that one's epistemological beliefs emerge through a developmental processes that leads from simpler beliefs to more complex beliefs about knowledge (see Schommer, 1994 for a review of the literature). At what phase in personal epistemological belief development are we likely to find middle-school students? Some researchers have related progress through epistemic belief stages to Piagetian stages of development (Boyes & Chandler, 1992). Individuals may leave the most naive stage of epistemic beliefs, that knowledge is absolute and handed down by authority as they reach the formal operational stage of development. For many students who reach the formal operational stage, the first evidence of formal operational thought is evident in junior high or high school (Woolfolk, 1993). Middle school students might be expected to be in a transition period between acceptance of knowledge as absolute and a more advanced belief. Other researchers, however, have contended that the shift to more advanced epistemological beliefs occurs later than middle-school (Schommer, 1994).

In a high school sample, Schommer found that beliefs in simple knowledge, quick all-or-none learning, and certain knowledge decreased from the freshman year to the senior year.

Research in cognitive preferences sheds some light on the typical level of epistemological belief development of middle-school age students. A cognitive preference, as defined by Tamir (1985), represents a student's preferred mode of learning new information, whereas an epistemological belief is a belief about the way in which knowledge is acquired. His conception of cognitive preferences divided preferences into four areas, one of which was a preference for simple recall of information, as opposed to understanding relationships or applications. A student who prefers to accept knowledge on this basis is one who, in Schommer's terms, is likely to see knowledge as simple rather than integrated. Tamir, in a meta-analytic study of cognitive preferences, suggested that the cognitive preferences of students change from junior high to high school. Junior high students in the Tamir study were more likely than high school students to indicate such a preference for simple recall than were high school students.

<u>Relationship of personal epistemological beliefs to learning</u>. Schommer (1994) argued that epistemological beliefs relate to learning in several ways. First, epistemological beliefs are related to the extent to which an individual actively engages in learning. A belief that knowledge is absolute and that authority is the only source of knowledge leads to a passive acceptance of factual information.

Second, epistemological beliefs are related to persistence in learning tasks. It is in the dimensions of fixed ability and quick all-or-none learning that the constructs of self-efficacy and epistemological beliefs meet. The control of learning dimension varies from the belief that ability is a fixed entity to the belief that ability is acquired through experience. Dweck & Leggett (1988) developed a theory about beliefs in intelligence or ability. Fixed theorists are people who believe that intelligence and the ability to learn are fixed. (Such people would be expected to show naive beliefs on the fixed ability dimension of Schommer's epistemological belief scale). A fixed theorist approaches a task with a performance goal, a need to demonstrate intelligence or ability. When faced with a task that is difficult, a fixed theorist is likely to decide that he or she is not capable of performing the task, and will quit trying. A student with a performance goal orientation is not only less likely to persist at a difficult task, he or she is also less likely to seek or accept tasks that are challenging. An individual with a performance goal orientation will prefer tasks in which there is a low risk of failure.

An incremental theorist believes that intelligence and capabilities can be improved with experience. (Such a person should indicate sophisticated beliefs on the fixed-ability dimension of Schommer's scale). The purpose of an academic task, for an incremental theorist, is to improve ability or intelligence. Such a learner, according to Dweck and Leggett (1988), is likely to approach a task with a learning goal. When faced with a difficult task, such a student decides to try harder. Thus, an incremental theorist is more likely to persist.

Evidence for a relationship between belief in fixed or incremental ability and task choice is provided by Dweck and Leggett (1988), who discussed a study conducted by Leggett (1985). Leggett studied the relationship between theories of intelligence and task choice among junior high students. She found that students with a theory of fixed intelligence were more likely than those with an incremental theory to choose tasks that were not too hard, so that they would be sure to perform well. Junior high students with an incremental theory of intelligence were more inclined than those with a fixed theory to choose challenging tasks.

Epistemological beliefs have been shown to be related to learning in math and science. Songer and Linn (1991) investigated the relationship between the epistemological beliefs of eighth grade students and their retention of factual knowledge and integration of knowledge during a thermodynamics unit. Songer and Linn hypothesized that students might hold either static or dynamic views of science. A student with a static view of science would believe that scientific principles in textbooks will always be true and that science is best learned by memorizing facts rather than attempting to understand complex information. They believe that scientists do not expect principles to explain a broad group of events. Students with a dynamic view see scientific knowledge as controversial. Such a student would understand that scientists compare results, that different interpretations exist for the same results, and that scientific principles may evolve and change. The static/dynamic dichotomy investigated by Songer and Linn overlaps two of the four dimensions of epistemological beliefs suggested by Schommer (1990). The static belief that principles will always be true and that views do not change is consistent with Schommer's fourth factor: knowledge is certain. The belief that scientific knowledge is best learned by memorizing facts and that principles should not be expected to explain a broad group of events seems consistent with Schommer's second factor: knowledge is discrete and unambiguous. Only about 15% of the eighth-grade students in Songer and Linn's study held a dynamic view of science. Static views were reported by 21% and the remainder reported mixed views. Thus, most of these middle-school students held relatively unsophisticated epistemological beliefs. Songer and Linn found that a student's epistemological beliefs were not related to the accuracy of recall of factual information about thermodynamics, but beliefs were related to the extent to which a student was able to integrate new information. Students who showed dynamic epistemological beliefs about science were better able than students with static beliefs to apply new information about thermodynamic principles to new situations in the classroom and the natural world. Unfortunately, it is not clear whether belief in static or dynamic knowledge is confounded with ability in the Songer and Linn study. It is possible that students of higher ability had more of a tendency to believe in dynamic knowledge than did students of lower ability, which would explain the relationship between epistemological beliefs and application of new information.

Epistemological beliefs may be related to a student's major area of study. Jehng, Johnson, and Anderson (1993) used Schommer's multidimensional definition of epistemological beliefs to study differences among college students of different levels and majors. Graduate students were more likely than undergraduates to believe in uncertainty of knowledge, to believe that knowledge comes from reasoning rather than from authority, and that learning is not an orderly process. When comparing the beliefs of students in the fields of engineering and business with those in the fields of social science or humanities, they found that students in engineering and business were more likely to believe that knowledge is certain, handed down by authority, and that learning is an orderly process.

Jehng et al.(1993) explained the differences in epistemological beliefs as a result of differences in educational experiences. Work in introductory courses is often well-organized and sequential, and often consists of knowledge handed down by an expert. Students are told, via lecture or text, exactly what they need to learn. The content and manner of presentation may lead students to believe that knowledge is handed down by authority and that learning is an orderly process. Likewise, contended Jehng et al., engineering and business are fields in which concepts are taught as structured and sequential. Students are taught to follow prescribed procedures to obtain answers that are clearly right or wrong. "Learning is viewed as a process in which an individual follows a limited set of orders to pursue already-formulated truths" (Jehng et al., p. 33). Social sciences and humanities are fields that are less sequential and in which problems are often ill-structured. Theories in the social sciences often contradict each other. Students in social sciences and humanities would learn that knowledge is found independently and is often uncertain. It should be noted, however, that the Jehng, et al. data are correlational. It is entirely possible that the differences in educational experience have not lead to differences in epistemological beliefs in the groups studied. Rather, it may be that students with differing epistemological beliefs choose different fields of study or that students with more sophisticated beliefs are more likely to attend graduate school.

It should also be noted that Jehng et al. did not block subjects by sex. It is likely that the majority of engineering and business students in the sample were male. Nationally, males make up 57% of students awarded business and engineering degrees, but only 39% of students in the arts and 33% of students in English and letters (National Center for Education Statistics, 1993). The differences found in epistemological beliefs could well be related to the representation of women in the subject areas considered.

Cognitive preference, a construct related to epistemological beliefs, may be related to subject area interest. Tamir discussed four modes identified by Heath (1964) that a student could apply to new scientific information. Of particular interest is the comparison of the "Recall" mode with the three other modes, including "Principles," "Questioning," and "Application." The Recall mode incorporates Schommer's notions of simple, isolated, and certain knowledge, handed down by authority, and is consistent with naive epistemological beliefs. The other three modes incorporate Schommer's notions of reasoned knowledge that is integrated with other knowledge, and are consistent with sophisticated epistemological beliefs. The Principles mode of attending to scientific information involves acceptance of information because it explains a fundamental principle or relationship. The Questioning mode involves questioning the completeness, validity, or limitation of scientific information. Application involves the acceptance of new information in terms of its usefulness or applicability.

Tamir's conception of cognitive preferences would seem to be related to Schommer's conception of epistemological beliefs. A student's beliefs should be reflected in what the student prefers to do intellectually with new information. Tamir found that 12th grade students who intended to pursue science careers were less likely to prefer the Recall orientation than were non-science majors. No gender differences were found in cognitive preference in the Tamir study. Students who intended to study science in college showed a lower preference for recall than students who did not intend to pursue scientific fields. Higher achievement in science was also predicted by a lesser preference for the Recall mode.

Although epistemological beliefs may be different for students majoring in different subject areas, an individual's epistemological beliefs do not appear to be domain-specific. Schommer and Walker (1994) measured the epistemological beliefs of 114 undergraduates, asking them to complete the epistemological beliefs questionnaire twice: once with mathematics in mind, and once with the social sciences in mind. They found that each epistemological belief dimension in mathematics correlated significantly with the corresponding dimension in social sciences. Schommer and Walker also asked participants to read one mathematics passage and one social science passage and to complete a corresponding posttest for each passage. Epistemological beliefs measured for mathematics predicted performance on a social science posttest and epistemological beliefs measured for social science predicted performance on the mathematics posttest. Schommer and Walker concluded that epistemological beliefs are probably independent of domain.

Influence of Teachers, Parents, and Peers on Science Participation

Parents, counselors, teachers, and peers may all influence the choices students make about course enrollment. In the Ajzen and Fishbein (1980) Theory of Reasoned Action, the influence of others on course decisions acts through the subjective norm component. Parents have different academic expectations for their sons than they have for their daughters (Parsons et al., 1982). Even among gifted populations, parents of girls are likely to expect their sons to enter math or science-related fields, but expect girls to work a while, then drop out to raise a family (Brody & Fox, 1980). In the area of math, parents believe their middle school and high school sons have more ability in math than do their daughters, even though objective measures of ability show no difference (Parsons et al.). Parsons et al. found that parents of daughters thought their children expended more effort to perform well in math, although objective measures showed no difference.

Differential attributions to ability and effort may have an important impact on the behavior of students. An effort attribution leaves future performance in doubt. If students believe they are already as working very hard to keep up with a class at present, they may doubt their own ability to perform well on increasingly difficult tasks in a domain. In the Parsons et al.(1982) study, students' expectancies for future performance in math were related to parental beliefs about their child's abilities. When parents thought that math was hard for their child and that their child had low ability in math, children were more likely to have a low estimate of their own ability and low expectations for future success in math. Parent beliefs about children's abilities were better predictors of the child's math self-concept and expectancies than were the child's actual previous performance.

In science, parent attitudes toward science are correlated with the attitude toward science expressed by the middle-school student and are generally somewhat stronger for same-sex pairs (Simpson & Oliver, 1990). Parent attitudes toward science were also correlated with student science achievement in the Simpson and Oliver study, and families of male students generally placed more importance than families of female students on science. Father's attitudes toward science correlated between 0.13 and 0.16 with student science achievement, a small but significant relationship.

Teachers' differential expectations of boys and girls may be expressed in subtle ways. From preschool through college, boys receive more time and attention from their teachers than do girls, and the differences may widen with grade (Sadker, Sadker, & Klein, 1991). Teachers differ in the types of interactions in which they participate with boys and girls in the classroom. Comments directed at boys tend to be more precise, more valuable, and more evaluative than comments made to girls. Teachers' interactions with students in the classroom give students cues about the teacher's expectations for the success of individual students. Dweck and Goetz (1978) reviewed previous studies of sex differences in teacher criticism of students. When boys made mistakes, the error was likely to be attributed by the teacher to a lack of effort. The message received by boys was that if they would only try harder, they would succeed. Girls, however, were not as likely to be told they could succeed if they tried harder, and girls were more likely to attribute failure to a lack of ability. With such causal attributions, boys are likely to increase effort, while girls are likely to conclude that because of a lack of ability, increased persistence would do no good.

It is possible to instruct teachers in methods that increase the classroom participation of girls. In a study conducted by Rennie and Parker (1987), girls in mixed-sex science groups participating in a physical science unit were less likely to actively manipulate equipment than were the boys. Girls in mixed-sex groups spent 14% more time simply watching and listening than did girls in same sex groups. Among the students of teachers who had participated in a two-day workshop on differences in attitudes and achievement of girls and boys in physical science, the gender differences in group participation disappeared.

Peer influence is especially critical to girls of middle-school age, the time that most must make decisions about classes (Costanzo & Shaw, 1966). Costanzo and Shaw investigated conformity among male and female students in 4 age groups ranging from 7 through 21 years. Males and females in the 11-13 age group were more likely than students of other ages to conform to the majority opinion. When students in this age group differed with other students, they were more likely to give an internal attribution for the difference. They believed that something was wrong with their own behavior, not with the behavior of their peers. Conformity may therefore be a significant variable in course enrollment decisions for students of middle-school or early high school age.

Simpson and Oliver (1990) provided evidence for the importance of peer conformity in middle school and high school age students. They found the correlation between student attitudes toward science and the science attitudes of their peers to be higher than the relationship between student and parent attitudes. Correlations between the attitudes of students and peers increased across the middle school years and were strongest at grade 9 in the Simpson and Oliver study, with a correlation of 0.68. Small but positive correlations were found for peer attitudes toward science and science achievement. Achievement and attitudes of girls in the Simpson and Oliver study were more influenced by the attitudes of other students than were the achievement and attitudes of boys, consistent with the finding of Crawley and Coe (1990) that girls' course enrollment decisions are more influenced by the opinions of others than were boys' enrollment decisions.

Although girls may be more influenced than boys by the opinions of others, peer pressure for success in science may be stronger for boys than for girls. Jegede and Okebukola (1992) assessed perceptions of peer expectations for success in science among high school students. They found that boys were more likely than girls to indicate that their friends expected them to do well in science.

Gender stereotypes are a subtle influence that may be evident in the behavior of parents, teachers, and peers. To the extent that others who influence the student hold gender role stereotypes, considering math and science a male domain, the student will be exposed to stereotyped information about the subjects and the occupations.

Conclusions

Fishbein and Ajzen's Theory of Reasoned Action appears to be a useful model for the study of the relationship between attitude and behavior in science education. It improves upon earlier studies of science attitudes and course enrollment behavior by specifying the relationships between affective, cognitive, and behavioral components of attitudes. In traditional models of attitude, affective, cognitive, and behavioral components are responses related to the underlying construct of attitude, and all manifestations are expected to be consistent with the attitude. The lack of consistency between measures of attitude and participation and achievement in science seems to contradict this assumption. The Fishbein and Ajzen (1975) model of attitudes specifies relationships between the components of an attitude. The cognitive component, consisting of beliefs about outcomes of behavior, contribute to affect concerning a behavior. The affective components, in turn, predict behavior. Fishbein and Ajzen argued that not only does affect influence behavioral intent, but beliefs about the expectations of others may also influence intent. A person may hold many different beliefs about the outcomes of engaging in a behavior, some leading to positive affect or social influence, and some leading to negative affect or social influence. Affect and behavior need not be consistent. A student may have a generally positive evaluation of the outcomes of enrollment in a science class, but no intention of enrollment if other people discourage the behavior. Likewise, a student whose evaluation of enrollment outcomes is negative may still intent to enroll if others are encouraging of the behavior.

The Theory of Reasoned Action is a useful model for investigation of the variables that influence beliefs about science course enrollment. If science educators want to change patterns of participation, it is not enough to know whether sex, race, interest, or ability are related to the behavior. Knowing that there is a relationship does not tell the educator how to modify the behavior. It is more useful to investigate and understand the determinants of the behavior in which we are interested. For example, if researchers find that girls are more affected by parents' opinions of science participation than are boys, then some of our efforts to increase participation of women must be focused on encouraging positive messages about enrollment from their parents. The Ajzen and Fishbein theory provides a very specific model that helps researchers and educators to focus on the variables involved in decision-making at crucial points on the path to science careers.

The Ajzen and Fishbein (1980) theory provides science educators a model for investigation of external variables that may show small correlations with science achievement, but that are nevertheless of theoretical and practical interest. External variables such as self-concept, self-efficacy, and epistemological beliefs may be related to science achievement and participation in ways that are not evident in studies that look at only the external variable and the behavior. Such variables may have subtle effects on the determinants of attitudes and subjective norm.

Appropriate intervention can influence the interest, achievement, and participation of boys and girls in science (Hamrick & Harty, 1987; Mason & Kahle, 1988; Martinez, 1992). Understanding the specific beliefs that predict course enrollment behavior can help science educators plan more effective interventions for all students.

References

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179-211.

Ajzen, I., & Fishbein, M. (1980). Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice-Hall, Inc.

American Association of University Women. (1990). Shortchanging Girls, Shortchanging America. A nationwide poll to assess self esteem, educational experiences, interest in math and science, and career aspirations of girls and boys ages 9-15. (ERIC Document Reproduction Service No. ED 340 657)

Archer, J., & Freedman, S. (1989). Gender-stereotypic perceptions of academic disciplines. British Journal of Educational Psychology, 59, 306-313.

Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, 37(2), 122-147.

Bandura, A. (1986). Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, MS: Prentice-Hall.

Benbow, C.P. & Stanley, J.C. (1980). Sex differences in mathematical ability: Fact or artifact? Science, 210, 1262-1264.

Boyes, M.C., & Chandler, M. (1992). Cognitive development, epistemic doubt, and identity formation in adolescence. Journal of Youth and Adolescence, 21, 277-304.

Brody, L., & Fox, L.H. (1980). An accelerative intervention program for mathematically gifted girls. In L. Fox, L. Brody, & D. Tobin (Eds.), Women and the Mathematical Mystique (pp. 164-178). Baltimore: Johns Hopkins.

Collis B., & Williams, R. (1987). Cross-cultural comparison of gender differences in adolescents' attitudes toward computers and selected school subjects. Journal of Educational Research, 81(1), 17-27.

Costanzo, P.R., & Shaw, M.E. (1966). Conformity as a function of age level. Child Development, 37, 967-975.

Crawley, F.E. (1990). Intentions of science teachers to use investigative teaching methods: A test of the theory of planned behavior. Journal of Research in Science Teaching, 27(7), 685-697.

Crawley, F.E., & Coe, A.S. (1990). Determinants of middle school students' intention to enroll in a high school science course: An application of the Theory of Reasoned Action. Journal of Research in Science Teaching, 27(5), 461-476.

Dweck, C.S., & Goetz, T.E. (1978). Attributions and learned helplessness. In J. Harvey, W. Ickes, R. Kidd (Eds). New Directions in Attribution Research, 2, (pp.157-179). Hillsdale, NJ: Earlbaum.

Dweck, C.S., & Leggett, E.L. (1988). A social-cognitive approach to motivation and personality. Psychological Review, 95(2), 256-273.

Eccles, J.S. (1985). Why doesn't Jane run? Sex differences in educational and occupational patterns. In F.D. Horowitz & M. O'Brien, (Eds.), The Gifted and Talented: Developmental Perspectives. Washington, DC: American Psychological Association.

Eccles, J.S., Barber, B., Updegraff, K., & O'Brien, K.M. (1995, April). An expectancy-value model of achievement choices: The role of ability self-concepts, perceived task utility and interest in predicting activity choice and course enrollment. Paper presented at the 1995 annual meeting of the American Educational Research Association, San Francisco, CA.

Feldhusen, J., & Willard-Holt, C. (1993). Gender differences in classroom interactions and career aspirations of gifted students. Contemporary Educational Psychology, 18, 355-362.

Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, Mass.: Addison-Wesley.

Fiske, S.T. & Taylor, S.E. (1991). Social Cognition. New York: McGraw-Hill, Inc.

Gardner, P.L. (1975). Attitudes to science: A review. Studies in Science Education, 2, 1-41.

Gauld, C. (1982). The scientific attitude and science education: A critical reappraisal. Science Education, 66, 109-121.

Gauld, C., & Hukins, A. (1980). Scientific attitudes: A review. Studies in Science Education, 7, 129-161.

Hamrick, L., & Harty, H. (1987). Influence on resequencing general science content on the science achievement, attitudes toward science, and interest in science of sixth grade students. Journal of Research in Science Teaching, 24(1), 15-15.

Haselhuhn, C.W., Andre, T., Whigham, M., & Veldhuis, G.H. (1995, April). Attitudes of middle-school students and their parents about education in physical science, biological science, and mathematics. Paper presented at the annual conference of the American Educational Research Association, San Francisco, CA.

Heath, R.W. (1964). Curriculum, cognition, and educational measurement. Educational and Psychological Measurement, 24(2), 239-253.

Hill, O., Pettus, C., & Hedin, B. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. Journal of Research in Science Teaching, 27(4), 289-314.

International Association for the Evaluation of Educational Achievement. (1988). Science Achievement in Seventeen Countries. Oxford: Pergamon Press.

Jegede., O., & Okebukola, P. (1992). Differences in sociocultural environment perceptions associated with gender in science classrooms. Journal of Research in Science Teaching, 29(7), 637-647.

Jehng, J.J., Johnson, S.D., & Anderson, R.C. (1993). Schooling and students' epistemological beliefs about learning. Contemporary Educational Psychology, 18, 23-35.

Kahle, J., & Lakes, M. (1983). The myth of equality in science classrooms. Journal of Research in Science Teaching, 20(2), 131-140.

Kahle, J.B., & Meece, J. (1994). Research on gender issues in the classroom. In D. L. Gabel, (Ed.), Handbook of Research on Science Teaching and Learning (pp. 542-557). New York: MacMillan Publishing Co.

Kelly, A. (1986). The development of girls' and boys' attitudes to science: A longitudinal study. European Journal of Science Education, 8, 399-412.

Kitchener, K.S. & King, P.M. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. Journal of Applied Developmental Psychology, 2, 89-116.

Koballa, T.R. (1988). The determinants of female junior high school students' intentions to enroll in elective physical science courses in high school: Testing the applicability of the Theory of Reasoned Action. Journal of Research in Science Teaching, 25(6), 479-492.

Lawrenz, F. (1987). Gender effects for student perception of the classroom psychosocial environment. Journal of Research in Science Teaching, 24(8), 689-697.

Lent, R.W., Brown, S.D., & Larkin, K.C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. Journal of Counseling Psychology, 31(3), 356-362.

Lent, R.W., Brown, S.D., & Larkin, K.C. (1987). Comparison of three theoretically derived variables in predicting career and academic behavior: Self-efficacy, interest congruence, and consequence thinking. Journal of Counseling Psychology, 34(3), 293-298.

Lent, R., Larkin, K., & Brown, S. (1989). Relation of self-efficacy to inventoried vocational interests. Journal of Vocational Behavior, 34, 279-288.

Levin, T., Sabar, N., & Libman, A. (1991). Achievements and attitudinal patterns of boys and girls in science. Journal of Research in Science Teaching, 28 (4), 315-328.

Linn, M.C., & Petersen, A.C. (1985). Facts and assumptions about the nature of sex differences. In S.S. Klein (Ed.), Handbook for Achieving Sex Equity Through Education (pp. 53-77). Baltimore: Johns Hopkins University Press.

Lubinski, D., & Benbow, C.P. (1992). Gender differences in abilities and preferences among the gifted: Implications for the math-science pipeline. Current Directions in Psychological Science, 1(2), 61-66.

Martinez, M.E. (1992). Interest enhancements to science experiments: Interactions with student gender. Journal of Research in Science Teaching, 29(2), 167-177.

Mason, C.L., & Kahle, J.B. (1988). Student attitudes toward science and science-related careers: A program designed to promote a stimulating gender-free learning environment. Journal of Research in Science Teaching, 26(1), 25-39.

Mullis, I.V.S., Dossey, J.A., Campbell, J.R., Gentile, C.A., O'Sullivan, C., & Latham, A.S. (1994). NAEP 1992 Trends in Academic Progress. (National Center for Education Statistics Report No. 23-TR01). Washington DC: US Government Printing Office.

Mullis, I., & Jenkins, L. (1988). The science report card: Elements of risk and recovery. Princeton, NJ; Educational Testing Service.

Napier, J.D., & Riley, J.P. (1985). Relationship between affective determinants and achievement in science for seventeen-year-olds. Journal of Research in Science Teaching, 22(4), 365-383.

National Center for Education Statistics. (1993). Digest of Educational Statistics (NCES 93-292). Washington, DC: Department of Education Office of Research and Improvement.

National Science Foundation. (1988). Women and Minorities in Science and Engineering. (NSF 88-301). Washington, DC: Author.

National Science Foundation. (1992). Indicators of Science & Mathematics Education. (NSF 93-93). Washington, DC: Author.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. Review of Research in Education, 16, 153-222.

Oliver, J.S., & Simpson, R. (1988). Influences of attitude toward science, achievement motivation, and science self concept on achievement in science: A longitudinal study. Science Education, 72(2), 143-155.

Olson, J.M. & Zanna, M.P. (1993). Attitudes and attitude change. Annual Review of Psychology, 44, 117-154.

Parsons, J., Adler, T., & Kaczala, C. (1982). Socialization of achievement attitudes and beliefs: Parental influences. Child Development, 53, 310-321.

Peltz, W. (1990). Can girls + science - stereotypes = success? The Science Teacher, 57(9), 44-49.

Rennie, L., & Parker, L. (1987). Detecting and accounting for gender differences in mixed-sex and single-sex groupings in science lessons. Educational Review, 39(1), 65-73.

Rosser, S.V. (1990). Female-Friendly Science. New York: Pergamon Press.

Ryckman, D., & Peckham, P. (1987). Gender differences in attributions for success and failure situations across subject areas. Journal of Educational Research, 81(2), 120-125.

Sadker, M., Sadker, D., & Klein, S. (1991). The issue of gender in elementary and secondary education. Review of Research in Education, 17, 269-334.

Schibeci, R. (1984). Attitudes to science: An update. Studies in Science Education, 11, 26-59.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82(3), 498-504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. Journal of Educational Psychology, 85(3), 406-411.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. Educational Psychology Review, 6(4), 293-319.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. Journal of Educational Psychology, 84(4), 435-443.

Schommer, M., & Walker, K. (1994, October). Comparing epistemological beliefs about mathematics and social sciences. Paper presented at the Mid-Western Educational Research Association Annual Meeting, Chicago.

Schunk, D.H. (1989). Self-efficacy and cognitive skill learning. In C. Ames & R. Ames, (Eds.), Research on Motivation in Education: Vol 3 Goals and Cognitions (pp. 13-44). San Diego: Academic Press.

Simpson, R.D., Koballa, T.R., Oliver, J.S., & Crawley, F.E. (1994). Research on the affective dimension of science learning. In D. L. Gabel, (Ed.), Handbook of Research on Science Teaching and Learning (pp. 211-234). New York: MacMillan Publishing Co.

Simpson, R., & Oliver, J. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. Science Education, 74(1), 1-18.

Songer, N., & Linn, M. (1991). How do students' views of science influence knowledge integration? Journal of Research in Science Teaching, 28(9), 761-784.

Tamir, P. (1988). The relationship between cognitive preferences, student background and achievement in science. Journal of Research in Science Teaching, 25(3), 201-216.

Tamir, P. (1985). Meta-analysis of cognitive preferences and learning. Journal of Research in Science Teaching, 22(1), 1-17.

Tippins, D. (1991, April). The relationship of science self-efficacy and gender to ninth grade students' intentions to enroll in elective science courses. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Tobin, K., Tippins, D., & Gallard, A. (1994). Research on instructional strategies for teaching science. In D. L. Gabel, (Ed.), Handbook for Research on Science Teaching and Learning (pp. 45-93). New York: MacMillan Publishing Co.

US Department of Education. (1993). Digest of Educational Statistics (NCES93-292). Washington, DC: Author.

van den Putte, Bas. (1993). On the Theory of Reasoned Action. Unpublished doctoral dissertation, University of Amsterdam.

Voss, M. (1995, January 29). Parents, teachers, kids, all contribute to the gender gap. The Des Moines Register, pp. 1A, 2A.

Voss, M. (1995, January 30). Few girls in many physics classes. The Des Moines Register, pp. 1T, 2T.

Weiner, B. (1985). An attributional theory of achievement motivation and motivation. Psychological Review, 92(4), 548-573.

Widnall, S.E. (1988). AAAS presidential lecture: Voices from the pipeline. Science, 241, 1740-1745.

Woolfolk, A.E. (1993). Educational Psychology. Needham Heights, MA: Allyn & Bacon.

RELATIONSHIPS OF GENDER, SCIENCE SELF-EFFICACY, PERSONAL EPISTEMOLOGICAL BELIEFS, ATTITUDE AND SUBJECTIVE NORMS TO INTENDED HIGH SCHOOL SCIENCE CLASS ENROLLMENT

A paper to be submitted to the Journal of Research in Science Teaching

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Abstract

Few students of either gender enroll in high school physics courses, but young women are especially underrepresented. A total of 698 freshmen from five Iowa high schools participated in a study in which Fishbein and Ajzen's Theory of Reasoned Action was applied to the study of the attitudes and social support that influence decisions to enroll in high school physics, chemistry, and biology classes. Attitude toward enrollment and social support for enrollment predicted enrollment intent, with gender, academic ability, and self-efficacy explaining a small but significant portion of additional variance. Examination of beliefs underlying attitudes and subjective norms suggests that for physics enrollments to increase, students need to feel that they would be successful if they took a physics class, class activities must be enjoyable for male and female students, and parents and students must be aware of the advantages of taking high school physics.

Introduction

Women are underrepresented in science education and careers, with the largest gender difference in physical science and physics. When the term "underrepresentation" is used in this paper, it is not implied that men and women must enter science careers in proportions equal to their representation in the population. Rather, it is argued that the educational and social experiences of many girls and women in our culture discourage some, who would otherwise have been qualified for and interested in training for science careers, from entering such careers. In 1986, women made up 25% of people employed in the life sciences, but only 13% of those employed in physical science (National Science Foundation [NSF], 1988). In 1989-1990, women obtained 50.8 % of the bachelor's degrees awarded in life science, but only 31.3 % of the bachelor's degrees in physical science, and only 16% of the bachelor's degrees awarded in physics (US Department of Education, 1993).

Oakes (1990) has argued that part of the reason for underrepresentation of women in science is that, compared with young men, women leave high school less well prepared to pursue degrees and careers in science. However, gender differences in high school science preparation are small. The 1992 National Assessment of Educational Progress (NAEP) report (Mullis, Dossey, Campbell, Gentile, O'Sullivan, & Latham, 1994) indicated that more girls than boys enroll in biology and chemistry classes in high school, but the pattern reversed for physics enrollment. In the 1992 NAEP sample, 91% of the males and 93% of the females had taken biology at age 17, and 47% of the males and 51% of the females had taken chemistry. Fifteen percent of the boys in the 1992 NAEP sample had taken or were currently taking high school physics, but only 12% of the girls had taken or were taking a physics class.

Although gender differences in high school science enrollment may be narrowing (Mullis et al., 1994), other indicators of less thorough preparation of females for science careers remain. The science achievement of high school girls, as measured by standardized tests, is less than that of boys (Mullis et al., 1994) and girls' attitudes toward science are less positive than those of boys (Simpson & Oliver, 1990). Girls have less experience in science outside the classroom (Kahle & Lakes, 1983).

Why are women underrepresented in the physical sciences? Gender differences in attitudes toward science are among the contributing factors considered by science education researchers (Kahle & Meece, 1994). When attitude toward science in general was measured, middle school and high school girls reported less positive attitudes than boys (Mullis & Jenkins, 1988; Simpson & Oliver, 1990). Haselhuhn, Andre, Whigham, and Veldhuis (1995) found that, although middle-school girls indicated more positive attitudes than boys toward biological science, boys were more positive than girls toward physical science. Attitude toward science may influence course enrollment decisions. Simpson and Oliver (1990), in a longitudinal study of middle and high school students, found that attitude at grade 10 predicted future course enrollment in science. Simpson, Koballa, Oliver, and Crawley (1994) pointed out that consistency between science attitudes and behavior had been difficult to demonstrate, and suggested the utility of Fishbein and Ajzen's (1975) Theory of Reasoned Action for investigation of the relationship between attitude toward science and science class enrollment.

Theory of Reasoned Action

Fishbein and Ajzen's (1975; Ajzen & Fishbein, 1980) Theory of Reasoned Action states that in order for attitude to predict behavior, attitude and behavior must be measured at the same level of specificity in terms of action, target (object of the action), context (the specific situation), and time. Of particular interest in this study is the prediction of enrollment (action) in a physics, biology, or chemistry course (target), in high school (context), during the sophomore, junior, or senior year (time).

According to Fishbein and Ajzen (1975), if a person has the resources and opportunities necessary for performance of a behavior, (i.e., the behavior is within volitional control), the behavior is best predicted by the intent to perform the behavior

(BI). It must be emphasized that the specific behavior in question in this study is enrollment in specific high school science classes, not successful completion of those classes. Most high school students have the resources necessary for enrollment in a science course, though not all have the resources necessary for successful completion (e.g., lack of adequate mathematics or study skills). Students sampled in the current study had the opportunity to choose their science courses after the freshman year. Choosing to enroll in a science class is a behavior under the volitional control of most high school students and is a behavior suitable for study with this model.

Intent to perform a behavior is predicted by two components, attitude toward behavior and subjective norm. Attitude toward behavior (AB) is an affective component, reflecting one's feelings of favorableness or unfavorableness toward the behavior. The second predictor of intent is subjective norm (SN), a social component reflecting the beliefs one has about the support of others for engaging in a behavior. Because the attitude toward behavior and subjective norms components may interact, the interaction term is sometimes included in the model, represented in the following equation: $BI = w_1AB + w_2SN + w_3(AB*SN)$.

Attitude toward behavior is made up of beliefs about the possible outcomes of engaging in the behavior. If the behavioral intent in question is that of enrollment in a high school physics class, attitude is made up of beliefs about which outcomes might occur as a result of enrollment (b), and corresponding evaluative beliefs about whether those outcomes are positive or negative (e). The relationship between the attitude component and its associated beliefs is represented by the equation: $AB = \Sigma(b)(e)$. Each product of an outcome belief and evaluation of that outcome is considered a determinant of the attitude.

The subjective norm component is also made up of sets of beliefs. Students have normative beliefs (nb) about which other people or groups want them to engage in the behavior, and have corresponding beliefs about their motivation to comply with others' expectations (mc). The product of a normative belief and its corresponding motivation to comply constitutes a determinant of the subjective norms component. The relationship between the subjective norms components and its associated beliefs is described by the equation: $SN = \Sigma(nb)(mc)$.

According to the Ajzen and Fishbein (1980) model, variables such as gender, race, ability, interest, or self-concept do not directly affect intent to engage in a behavior. Such demographic variables and personality traits are considered external variables that may influence behavioral intent only through their influence on attitude or subjective norm components. External variables may exert influence on the determinants of attitude and subjective norms or may modify the relative importance of these two components to the prediction of intended behavior. Figure 1 describes the relationships among the internal variables of intent, attitude, subjective norms, and beliefs, and some external variables relevant to the study of science class enrollment decisions.

The Theory of Reasoned Action is useful in the study of high school enrollment decisions because it allows the researcher to investigate the components of such decisions. If attitude toward enrollment and subjective norms associated with science enrollment decisions predict intent to enroll, then the investigation of the beliefs that underlie attitude and subjective norms components should shed light on group differences, such as gender differences, in enrollment decisions.

Fishbein and Ajzen's (1975; Ajzen & Fishbein, 1980) Theory of Reasoned Action has been successfully applied to research in science attitudes and behavior. Crawley and

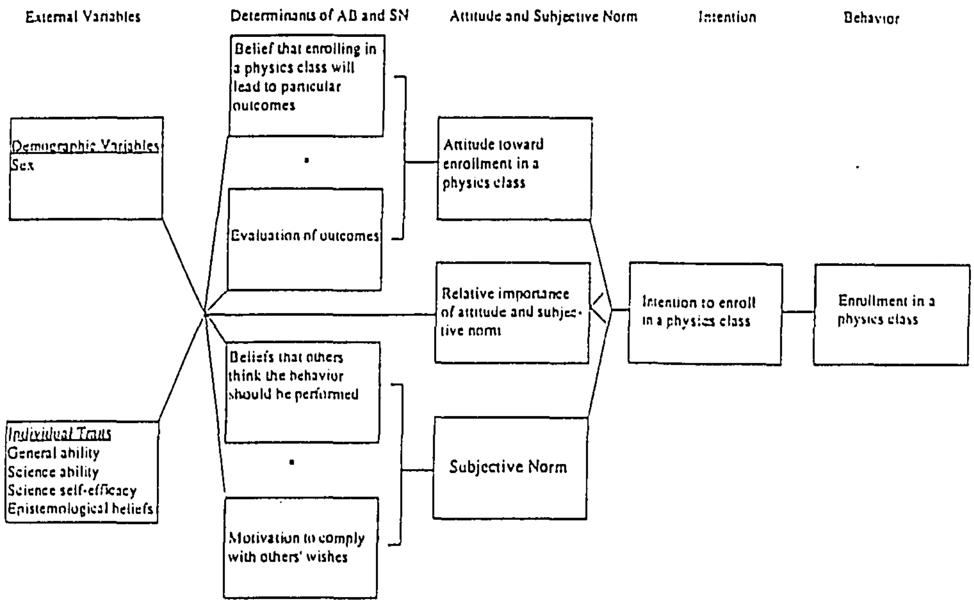

Figure 1. <u>The Fishbein and Ajzen Theory of Reasoned Action Applied to Physics Enrollment Decisions</u>.

Coe (1990) applied the model to predict 100 Texas middle school students' intentions to enroll in a nonrequired high school science course during the next school year. In addition to measuring intent, attitude, and subjective norms, Crawley and Coe assessed students' personal beliefs about the impact of taking a high school science course on learning new information, preparing for college, learning to do experiments, and meeting new students. They also considered the influence of family members, college admissions officers, counselors, close friends and teachers. Attitude and subjective norms were found to predict intended science class enrollment, with the external variables sex, ethnicity, science ability, and general academic ability adding nothing to prediction after attitude and subjective norm were considered. Among students in this sample, the subjective norms component was a more important predictor for female students than for male students, indicating that females were more influenced in their enrollment decisions by other people than were male students. Gender differences and science ability group differences were evident in determinants underlying the attitude component. Females were more likely than males to value learning new information in science and males were more influenced than females by the belief that science classes might be more difficult than other classes. Students with low science ability were more likely than high ability students to value learning more about science and learning how to do experiments. Crawley and Coe did not investigate gender or ability differences in beliefs underlying subjective norms.

Koballa (1988), with a sample of 94 Texas middle school girls, investigated the relationship between attitude toward enrollment in physical science courses, subjective norms concerning enrollment, and intent to enroll in a physical science course in high school. Koballa also measured the underlying determinants of attitude and subjective norms components and investigated the effects of ability group, science ability, and general attitude toward science. Koballa found that none of the external variables correlated with attitude toward enrollment or with the subjective norms components, nor did any of the external variables correlate with intent to enroll in a physical science class. Attitude toward enrollment and subjective norms were the sole predictors of intent to enroll in a physical science class, accounting for 42% of the variance in intent. Attitude was the better of the two predictors. This result is consistent with the results of a recent meta-analysis conducted by van den Putte (1992). In a meta-analysis of 113 studies applying the Theory of Reasoned Action, van den Putte observed that that behaviors with large personal relevance, such as studying, were largely influenced by attitude. Recreational behaviors that are performed with peers, such as use of alcohol, were largely influenced by the subjective norms component.

Crawley and Black (1992) applied the Theory of Planned Behavior (Ajzen, 1991) to the study of high school students' intention to enroll in physics classes. The Theory of Planned Behavior is an extension of the Theory of Reasoned Action that includes a behavioral control component. It is especially applicable for situations in which a person may not have complete volitional control over the intended behavior. Crawley and Black applied a causal modeling approach to investigation of relationships between model variables and five external variables, including grade (8-10), career goal, educational goal, gender, and ethnicity. Career goal and grade level were related to beliefs underlying attitudes, with attitudes generally becoming less positive as students progressed in grade level. Gender, ethnicity and educational goal were not related to beliefs. Although attitude and behavioral control components made significant contributions to prediction of intent to enroll in a physics class for this sample, the subjective norms component did not.

Results of previous applications of the Theory of Reasoned Action and the Theory of Planned Behavior to science class enrollment decisions suggest that such decisions are generally under both attitudinal and normative control (Crawley & Coe, 1990; Koballa, 1988). The two components have explained between 35% and 45% of the variance in intent. Attitude has generally been the better predictor of intent (Koballa, 1988; Crawley & Black, 1992). Perceived social support may be a stronger influence on enrollment intent for females than for males (Crawley & Coe, 1990). Although Crawley and Coe found that the subjective norm component predicted science enrollment intent for eighth-grade females but did not predict enrollment intent for eighth-grade males, they did not report a significant differences in subjective norm beta weights for males and females.

Consistent with predictions from the Fishbein and Ajzen (1975) model, external variables including gender, ethnicity, science ability, general academic ability, and general attitude toward science have not been found to predict enrollment intent after the effects of attitude and subjective norm are removed (Crawley & Coe, 1990; Koballa, 1988). Also consistent with predictions made by the model, Crawley and Coe (1990) concluded that the relative contributions of attitude and subjective norm differ among students grouped on the basis of gender, ethnicity, general ability, or science ability. Crawley and Coe tested the effects of external variable groups on relative influence of attitude and subjective norm by conducting separate regression analyses for each group and then comparing the significance of attitude and subjective norm beta weights in the prediction of intent for separate groups. However, they do not provide evidence that the differences observed in beta weights among groups are significant, so predictions can not be made solely on the basis of this evidence.

External variables, considered by Fishbein and Ajzen (1975) to act as indicators of differences in life experiences, have been shown to be related to beliefs underlying attitude and subjective norm components, although the results are not always consistent. Science ability and gender had a significant effect on attitude beliefs in the Crawley and Coe (1990) study. Gender, ethnicity, and educational goals were not related to beliefs in the Crawley and Black (1992) study, but career goal and grade level were related to beliefs.

Two questions arise from previous research concerning high school science course enrollments. First, why do far fewer students of both genders choose to enroll in physics courses than in chemistry and biology courses in high school? In order to investigate the first question, student attitudes and perceived social support for enrollment should be examined for each science subject area separately. Do students believe more positive outcomes are likely if they enroll in biology or chemistry than if they enroll in physics? Do students think that important others are more encouraging of biology and chemistry enrollment than of physics enrollment? Second, why do slightly more females than males choose to enroll in biology and chemistry classes but slightly fewer females than males enroll in physics classes? Female science enrollment drops drastically between chemistry enrollments of 51% of high school females and physics enrollments of 12% of all high school females. The enrollment drop between chemistry and physics is nearly as great for high school males. If there are differences in attitude and subjective norms components across science subject areas, are the changes similar for males and females? Might some of decline for females be explained by a larger drop for females than for males in attitude or perceived social support? Previous studies of science enrollment utilizing the Theory of Reasoned Action focused either on general science (Crawley & Coe, 1990) or on physics (Crawley & Black, 1992) or physical science (Koballa, 1988) but have not considered differences among science subject areas.

Purpose of the Study

This study focused on gender differences in attitudes and subjective norms and the prediction of intent to enroll in high school biology, chemistry, and physics classes in a sample of 9th-grade students. The focus on high school freshmen was considered appropriate because the study was conducted in schools in which students first have the opportunity to choose which science courses to take beginning in their sophomore year. The study extended, in two ways, previous studies of enrollment intent using the Theory of Reasoned Action. First, the current study assessed gender differences in attitude, subjective norms, and intent components for three areas of science class enrollment: physics, chemistry, and biology.

Second, the current study incorporated external variables already studied in relationship to science enrollment intent, such as gender, ability, and career goals, and added two relevant external variables: science self-efficacy beliefs and personal epistemological beliefs. High self-efficacy for a particular task predicts that a person will be more likely to choose to engage in the task and will be more likely to persist in the task. In their middle school and high school sample, Simpson and Oliver (1990) found that males showed higher science self-concepts than females. Tippins (1991) found that boys indicated higher science self-efficacy than did girls. Science self-efficacy is related to achievement and persistence in science and technology courses in college students (Lent, Brown, & Larkin, 1984; 1987). Levin, Sabar, and Libman (1991) found that science self-image, defined as students' perceptions of their ability to perform well in science, was the best predictor of science achievement for both boys and girls.

Because of different experiences, males may be expected to show higher science self-efficacy than females (Ryckman & Peckham, 1987; Eccles, 1985). Gender differences in self-efficacy may be greater in science areas such as physics and chemistry, that are considered male domains, than in biology, which is gender-neutral (Kahle & Meece, 1994). Students with high science self-efficacy beliefs are more likely than those with low self-efficacy beliefs to expect the outcomes of science class enrollment to be positive. Thus, science self-efficacy beliefs are predicted to be related to enrollment outcome beliefs.

Personal epistemological beliefs are an individual's beliefs about the "source, certainty, and organization of knowledge, as well as the control and rate of learning" (Schommer, 1994 p.293.) Schommer (1993) identified four factors underlying personal epistemological beliefs in a high school sample. The factors consist of continua of beliefs about knowledge. In the first continuum, called simple knowledge, knowledge may be considered simple and discrete or highly integrated and interwoven. In the second factor, certain knowledge, knowledge may be considered absolute and certain or constantly changing. The third factor, quick learning, is a continuum from belief that learning is quick or never, to belief that learning is a gradual process. The fourth factor, fixed ability, is a continuum of beliefs from ability as fixed to ability as acquired through experience.

Personal epistemological beliefs may be related to success in an academic subject area and to task persistence. In a study involving 1182 high school students, Schommer (1993) found that students with more sophisticated epistemological beliefs had higher grade point averages. Songer and Linn (1991) found that eighth-grade students with more sophisticated epistemological beliefs were better able to integrate new science information with prior knowledge than were students with naive epistemological beliefs. If epistemological beliefs are related to task persistence, successful integration of new information, and academic success, it is likely that students with sophisticated epistemological beliefs will also hold more favorable beliefs about the successful completion of science classes. Gender differences may be found in epistemological beliefs among high school students. Schommer (1993) found that high school girls were less likely than boys to believe in fixed ability or in quick learning.

Self-efficacy beliefs and epistemological beliefs are hypothesized to influence task persistence and may influence outcome beliefs related to enrollment decisions. Males are predicted to show higher science self-efficacy than girls in physics, but high school girls have been shown to have more sophisticated epistemological beliefs than males. This results in conflicting predictions about gender differences in task persistence. Adding to the confusion, epistemological beliefs are supposed to be consistent across subject areas (Schommer & Walker, 1994), but self-efficacy beliefs are domain-specific. Thus, although it may be predicted that greater science self-efficacy and more sophisticated epistemological beliefs will in general result in more positive enrollment outcome beliefs, the relationships among self-efficacy, epistemological beliefs, gender, and outcome beliefs are not clear.

The current study applied the Theory of Reasoned Action to the study of freshman students' attitudes toward enrollment in nonrequired physics, chemistry, or biology classes during high school. In addition to the investigation of the relationships between attitude, subjective norms, and intent components for the three subject areas, the determinants of attitude and subjective norms components were investigated for intent to enroll in physics. The effects of five external variables, including student gender, academic ability, science self-efficacy, personal epistemological beliefs, and career goals were considered.

Two hypotheses tested in this study were derived from the Fishbein and Ajzen Theory of Reasoned Action and are supported by previous studies of high school science enrollment decision (Crawley & Coe, 1990; Koballa, 1988):

1. Intent to enroll in high school physics, chemistry, and biology courses will be predicted by their respective attitude, component, subjective norms component, and their interaction term: $BI = w_1AB + w_2SN + w_3(AB*SN)$.

2. The addition of external variables to the 3-predictor model will not explain a significant amount of additional variance. Thus, the following equation will not explain significantly more of the variance in physics, chemistry, or biology enrollment intent than does the model in Hypothesis 1: $BI = w_1AB + w_2SN + w_3 (AB*SN) + w_4\text{Gender} + w_5\text{Ability} + w_6\text{Epistemological beliefs} + w_7\text{Self-efficacy} + w_8\text{Career goals}$.

Additional hypotheses, consistent with the Theory of Reasoned Action, were made on the basis of previous research:

3. Based on the results of Koballa (1988) and the meta-analysis conducted by van den Putte (1993), it is predicted that the attitude component will be more influential in enrollment intent than will the subjective norms component for both males and females. Because middle school and early high school age students tend to conform with peers (Costanzo & Shaw, 1966), the subjective norms component will also influence intent. Based on the results obtained by Crawley and Coe, it is predicted that the subjective norms components will be more influential for females than for males.

4. The external variables (EV) of gender, academic ability, physics self-efficacy, personal epistemological beliefs, and career goals will interact with attitude toward behavior and subjective norms components in the prediction of intent to enroll in physics. The following mathematical model describes this prediction for an individual external variable: $BI = w_1AB + w_2SN + w_3(AB*SN) + w_4(EV)(AB) + w_5(EV)(SN) + w_6(EV)(AB*SN)$.

5. External variables will influence the importance of individual determinants of attitudes toward enrollment and subjective norms for physics. In particular, high academic ability, positive self-efficacy beliefs, and sophisticated epistemological beliefs will be related to more positive outcome beliefs. This hypothesis will be tested by regressing each determinant on the external variables of physics self-efficacy, academic ability, epistemological beliefs, gender, and career goals.

6. Male and female student self-efficacy beliefs will not differ for biology, but males will indicate greater self-efficacy than females in physics.

7. Female students will have more sophisticated epistemological beliefs than will males.

Method

Participants

Six-hundred and eighty-five high school freshmen from five central Iowa schools (351 males, 327 females, 7 who omitted sex on the questionnaire) participated in the study. Students who did not indicate their gender were omitted from any analyses in which gender was a variable. A total of 702 students had the opportunity to participate, but twelve students chose not to participate. Five students produced unusable data by drawing patterns on the machine-scorable answer sheet rather than responding to the questionnaire items and were not included in analyses, resulting in participation by 97.8% of the eligible students. Participants were volunteers who gave informed consent according to guidelines approved by the Iowa State University Human Subjects Review Committee.

Participants attended one of five central Iowa high schools. Total enrollment in participating high schools ranged from 250 to 2000, with three rural, one suburban, and one urban district represented. All freshman students in the suburban and rural schools were eligible to participate. In the urban high school, students in five physical science sections taught by the same teacher were eligible to participate.

The proportion of students enrolled in physics who were female varied in the districts from 30% to 48%. The mean proportion total physics students who were female was 37.7%, which is consistent with Iowa's state average of 44% during the 1993-1994 academic year (Voss, 1995, January 30). The proportions of females students in each participating district enrolling in high school physics during the 1993-94 school year are displayed in Table A1 - Appendix A.

Students in the participating schools were similar in academic ability to students in Iowa schools. The average Iowa percentile rank on the composite ITED score was 57.0

for the five schools combined and the average Iowa science percentile rank of 55.8 was also near the state average. Participants had high educational goals. Over 35% of the sample planned to seek a graduate or professional degree and an additional 38% planned to seek a bachelor's degree after high school.

In each of the districts included, students are required to complete one or two years of high school science and virtually all freshman students enroll in a physical science or general freshman science class. The majority of the participants were taking freshman general science or physical science. Four participants were enrolled in biology rather than physical science. Average age of the students was 15.5 years (15.6 years for males and 15.4 years for females). By self-report, the sample was approximately 89% Caucasian, 2% Asian, 1% African American, and 8% Native American or other. Table A2 - Appendix A describes demographic characteristics of participating students by individual schools.

Materials

Attitude toward enrollment questionnaire: Preliminary questionnaire. The attitude toward enrollment questionnaire was designed according to guidelines outlined by Ajzen and Fishbein (1980, p. 261-263.). An open-ended questionnaire was administered to 20 students from a suburban district and 21 students from a rural district in order to identify students' salient beliefs about enrolling in high school physics. The specific classes involved were chosen by a science teacher in each district. The teachers were instructed to choose a typical section, one that was neither extremely high nor low in ability. In order to identify salient beliefs underlying the attitude component of intent to enroll in a high school physics class, students were asked to indicate what they believed to be the advantages and disadvantages of enrolling in a high school physics class. To identify salient beliefs underlying the subjective norms components, students placed a check mark beside descriptions of other people who might have an effect on their decision to participate in a physics class or they indicated a person or group that had not been described. The open-ended questionnaire administered in this portion of the study is included in Table B1 in Appendix B.

Analysis of preliminary questionnaire responses began by placing each student response on a separate slip of paper. The responses were then organized by grouping those that referred to highly similar beliefs, and the frequency of response within each belief group was recorded. Ajzen and Fishbein (1980) recommend that after the modal beliefs and frequencies are recorded, that enough beliefs be selected for the final questionnaire to account for at least 75% of the attitude and subjective norms beliefs listed by the respondents. This 75% guideline was followed in the current study.

Responses to the open-ended questionnaire were analyzed separately for the two schools to determine modal salient beliefs. For the first group, which consisted of one section from the suburban district, 9 salient attitude beliefs and 12 salient subjective norms beliefs were identified, with 6 attitude beliefs and 7 subjective norms beliefs accounting for over 75% of the responses. From the rural district responses, 10 attitude beliefs were identified and 12 subjective norms beliefs were identified, with 6 attitude beliefs and 7 subjective norms beliefs accounting for over 75% of the total responses. There was considerable overlap in the categories of salient attitude and subjective norms beliefs for the two schools. When beliefs making up 75% of responses are considered, the following attitude beliefs were most frequently mentioned for both groups: 1) physics information will be useful in everyday life, 2) physics is difficult, 3) a physics class will require a lot of time, 4) taking physics will help me get into a good college, 5) physics is important to my future career, and 6) taking physics will help me once I get to college. In addition to the beliefs listed above which were among the most salient for both sections of students, two other beliefs were included in the attitude questionnaire because they were listed among the most salient for one of the two schools: 7) taking physics will not be a lot of fun, and 8) taking physics will lower my grade point average.

Considerable overlap between the two schools in salient subjective norms beliefs was also found. Considering the beliefs that made up 75% of subjective norms beliefs, both groups included the following people or groups as an influence over enrollment decisions: 1) mother, 2) good friends, 3) father, 4) science teacher, and 5) college admissions officers. Three additional beliefs were included in the final questionnaire because they were listed among the most salient beliefs for one of the schools: 6) brother or sister, 7) boyfriend or girlfriend, and 8) high school counselor. People or groups that were not considered influential in physics enrollment decisions by either group included grandparents, teachers in other subjects, and a doctor or dentist. Tables C1 and C2 - Appendix C contain the results of the content analyses.

Final attitude toward enrollment questionnaire: The final attitude toward enrollment questionnaire contained 41 items. Items included the following:

1. Behavioral intention items: (3) One each for intent to enroll in high school physics, chemistry, and biology.

2. Attitude toward enrollment items: (3) One each for attitude toward enrollment in high school physics, chemistry, and biology.

3. Subjective norms items: (3) One each for subjective norms related to physics, chemistry, and biology.

4. Attitude toward behavior determinant items: (16) Eight items assessing beliefs about outcomes of physics enrollment and eight corresponding items evaluating outcomes.

5. Subjective norms determinant items: (16) Eight items assessing beliefs about whether other people wished the participant to enroll in physics, and eight corresponding items measuring motivation to comply with the other's wishes.

Intent items. Three specific behaviors were considered in the questionnaire: Enrollment in a physics class during high school, enrollment in a chemistry class during high school, and enrollment in a biology class during high school. Intent to enroll in a science class was measured with one direct question for each subject area. For example, the intent question included for physics was:

"I intend to enroll in at least one physics class during high school.
No, definitely not 1 2 3 4 5 6 7 Yes, I definitely will"

Attitude and subjective norms items. Attitude toward course enrollment and subject norms components in each area of science were each measured with a single question for each subject area. For example, attitude toward physics class enrollment was measured with the following question:

"My attitude toward enrolling in a physics course during high school is
Unfavorable 1 2 3 4 5 6 7 Favorable"

The subjective norms component of intent to enroll in a high school physics class was assessed with the following item:

"Most people who are important to me think I

Should NOT 1 2 3 4 5 6 7 Should

take a physics class in high school."

Determinant items. From the results of the preliminary questionnaire, eight salient attitude beliefs and eight salient subjective norms beliefs were identified for inclusion in the final questionnaire. For each attitude belief, two items were generated: One item required the student to indicate on a 7-point scale to what extent they believed a particular outcome was likely. The corresponding item required the student to indicate whether that particular outcome was good or bad. For instance, one of the salient attitude beliefs identified was that taking a physics class would involve a lot of hard work. Students were asked to indicate the extent to which they believed that taking a physics class would involve hard work by answering the following item:

"My taking a high school physics class means that I will have to work very hard to understand the new concepts taught

Very unlikely 1 2 3 4 5 6 7 Very likely"

The corresponding item asked students to indicate whether working hard to understand a new concept was a good or bad thing:

"Working hard to understand new concepts is

Bad 1 2 3 4 5 6 7 Good"

Two items were also generated for each subjective norms belief. One item asked the student to indicate on a 7-point scale the extent to which a particular other person or group thought that the student should enroll in a physics class. The corresponding item asked the extent to which the student was motivated to comply with the wishes of the other person or group. Thus, a total of 32 items on the final scale were related to identifying the determinants of the attitudes and subjective norms components of the Ajzen and Fishbein model.

The attitude toward enrollment scale is included in items 4-44 in Table B2 - Appendix B.

External Variables

Epistemological beliefs. Student epistemological beliefs were assessed by administration of the Epistemological Questionnaire Revised for Middle School Student, developed by Marlene Schommer (1995). The 40-item Likert-type scale is an adaptation of Schommer's Epistemological Questionnaire Revised for High School Students (1992). It consists of items making up 6 conceptually-driven subsets: Simple knowledge, certain knowledge, fixed ability, quick learning, omniscient authority, and question avoidance. Previous research using the high school version of Schommer's Epistemological Questionnaire suggested that fewer than 6 factors underlie epistemological beliefs. Schommer (1993) identified four factors in a high school population, including simple knowledge, certain knowledge, quick learning, and fixed ability. Qian and Alvermann (1995) identified only three factors using the same scale with a high school population in Georgia. In their study, simple knowledge and certain knowledge combined into one factor. Because omniscient authority and question avoidance have not been identified as factors underlying epistemological beliefs in previous research, and because administration time in the current study was limited, these two subsets of items were eliminated from the scale for the current study. The final epistemological scale thus consisted of 31 items from

4 subsets: 1) simple knowledge- ten items, 2) certain knowledge - five items, 3) fixed ability - nine items, and 4) quick learning - seven items. Reliability and validity data were not available for the middle school version of the scale because it was still in the developmental stages. However, subscale internal consistency reliabilities for the longer version used with high school populations range from .51 to .78 (Schommer, 1993) and validity evidence for the high school and college versions has accumulated through a series of studies (Schommer, 1990; 1992; 1993; Schommer & Walker, 1994; Qian and Alvermann, 1995). The version of Schommer's (1995) Epistemological Questionnaire Revised for Middle School Students that was used in the present study is included in items 51-81 in Table B2 - Appendix B.

Science self efficacy. A total of six items assessed self-efficacy for success in science classes. Physics self-efficacy, chemistry self-efficacy, and biology self-efficacy beliefs were each measured with two items. For each science subject area, students indicated on a 7-point scale the extent to which they believed they were capable of successful completion of the classwork required in the subject and the importance of successful completion of such classwork to their future. Science self-efficacy items are listed in items 45-50 in Table B2 - Appendix B.

Academic ability. Students in each of the five high schools completed the Iowa Tests of Educational Development (Riverside Publishing Company, 1993) in the fall of the freshman year. Students' national standard scores, national percentile ranks and Iowa percentile ranks were collected for quantitative thinking and science subtests, and for the test composite. The test composite score was used as a measure of overall academic ability.

Demographic data and other external variables. Items concerning student age, gender, race, educational plans, and career plans and were included in the questionnaire. Students were asked to indicate their educational plans after high school by choosing the best of 8 options, including entering the military, attending a trade or technical program, attending a junior college, or entering a 4-year or professional program. Students also indicated what type of career they were considering. Demographic and career questions are included in items 1-3 in Table B2 - Appendix B.

Procedure

Questionnaires were administered by the experimenter during regular science class times at the high schools. Students who chose to participate read and signed a consent form. Because of time constraints, students in the suburban high school completed only the demographic, career, and attitude scale items. All other groups completed the epistemological scale as well, with the total 81-item scale taking 25 to 45 minutes to complete.

Iowa Test of Educational Development (ITED) information was taken from school records and recorded by identification number so that it could be matched with student questionnaire responses. ITED information was available for 634 students in the sample. ITED scores were unavailable for some students because they had moved to the districts after tests were administered or because tests were not administered to some special education students.

Results

Because of the large number of statistical comparisons conducted, significance levels were set at $p < .001$ for analyses unless otherwise noted.

Scales

Epistemological beliefs scale The version of Schommer's (1995) Epistemological Beliefs scale administered in the study consisted of 31 items from four subsets, including simple knowledge, certain knowledge, fixed ability, and quick learning. Five items were eliminated from the scale because of negative correlations with the total scale. The remaining 26-item total scale had an internal consistency reliability of .76. Scores on the total epistemological belief scale could range from 26 to 130, with high scores indicating naive epistemological beliefs and low scores indicating more sophisticated epistemological beliefs. Mean total epistemological scale score for the 315 students who completed the scale was 74.11 (SD=13.90). Scores on the epistemological scale ranged from 41 to 114.

Epistemological belief subscales were computed by calculating the mean response for all items within each conceptual subscale, placing items in the four subscales defined by Schommer (1995). Fixed ability and quick learning subset scores had internal consistency reliabilities of .65 and .68, respectively. Simple knowledge (Cronbach alpha = .37) and certain knowledge (Cronbach alpha = .24) subscales were eliminated from further analyses because of poor reliabilities. Mean scale scores for the fixed ability and quick learning subscales indicated that students' beliefs tended toward the sophisticated end of the scale, with means of 2.62 and 2.75, respectively.

Science self-efficacy scale. A science self-efficacy scale was created by adding the six self-efficacy item scores, resulting in a possible range of 6 through 42, with higher scores indicating greater self-efficacy beliefs. Mean science self-efficacy score for the sample was 31.80, with a standard deviation of 7.59. Cronbach alpha for the 6-item self-efficacy scale was .88. Self-efficacy scores were calculated for individual science subject areas by summing the expected success score and the value score for each area, and could therefore range from 2 through 14. Although subject area intercorrelations were high, students apparently distinguished between the subject areas in their responses. A mixed-design science subject by gender MANOVA indicated a significant effect of science subject area (physics mean = 10.50, SD = 2.75; chemistry mean = 10.47, SD = 2.77; biology mean = 10.86, SD = 2.87), $F(2,1336) = 33.71$, MSE = 2.09, $p < .001$. Scheffe post hoc analyses indicated that biology self-efficacy was greater than physics or chemistry self-efficacy, $F(2,1348)=21.71$, MSE=2.09, $p<.01$; and $F(2,1348)=24.38$, MSE=2.00, $p<.01$, respectively. Physics self-efficacy and chemistry self-efficacy did not differ, $F(2,1348)=.11$, MSE=2.09, ns. Females indicated more positive self-efficacy beliefs than males, $F(1,688)=5.58$, MSE=19.09, $p<.02$. As summarized in Table 1, girls showed higher self-efficacy than boys in each of the science subject areas, although the difference was significant only for biology, $F(1,688)=5.57$, MSE=6.68, $p<.05$.

Attitude toward Enrollment Scale. Intent to enroll in high school physics, chemistry, and biology classes, attitude toward enrollment, and subjective norms were assessed with a 7-point scale item for each area. Means and standard deviations obtained on intent, attitude, and subjective norms items are listed in Table 1. A repeated measures ANOVA indicated that there were significant differences in intent to enroll among the three science areas, $F(2,1346) = 100.65$, MSE = 1.42, $p < .001$. Scheffe post hoc analyses indicated that students rated intent higher for biology than for physics or chemistry, $F(2,1347) = 198.75$, MSE = 1.42, $p < .01$), and $F(2,1346) = 62.79$, MSE = 1.42, $p < .01$, respectively. Intent to enroll in chemistry was higher than intent to enroll in physics, $F(2,1346) = 36.90$, MSE = 1.42, $p < .01$.

ANOVA indicated significant subject area differences in attitude, $F(2,1348) = 68.63$, $MSE = 1.53$, $p < .001$. Scheffe post hoc analyses indicated that attitude toward biology was more positive than attitude toward physics or chemistry, $F(2,1348) = 137.59$, $MSE = 1.51$, $p < .01$, and $F(2,1348) = 38.18$, $MSE = 1.51$, $p < .01$, respectively. Attitude toward chemistry enrollment was more positive than attitude toward physics enrollment, $F(2,1348) = 30.41$, $MSE = 1.51$, $p < .01$.

Table 1. Attitude toward Enrollment Scale Item Means and Standard Deviations by Gender, and Significance of Gender Differences (N=678)

Variable	Mean (Standard Deviation) Males	Females	Total
Intent to enroll			
physics	5.05 $(1.74)_a$	4.97 $(1.78)_a$	5.01 $(1.76)_a$
chemistry	5.43 $(1.68)_b$	5.38 $(1.73)_b$	5.41 $(1.70)_b$
biology	5.69 $(1.72)_b$	6.16 $(1.43)_c$***	5.92 $(1.60)_c$
Attitude toward enrollment			
physics	4.58 $(1.72)_a$	4.38 $(1.65)_a$	4.48 $(1.69)_a$
chemistry	5.03 $(1.64)_b$	4.67 $(1.72)_b$	4.86 $(1.69)_b$
biology	5.14 $(1.76)_b$	5.40 $(1.71)_c$**	5.27 $(1.74)_c$
Subjective norms item			
physics	4.97 $(1.50)_a$	5.17 $(1.42)_a$	5.07 $(1.47)_a$
chemistry	5.11 $(1.45)_a$	5.23 $(1.43)_a$	5.17 $(1.44)_a$
biology	5.14 $(1.50)_a$	5.58 $(1.42)_b$ ***	5.35 $(1.48)_b$
Science self-efficacy			
physics	10.34 $(2.86)_a$	10.67 $(2.61)_a$	10.50 $(2.75)_a$
chemistry	10.33 $(2.87)_a$	10.62 $(2.66)_a$	10.47 $(2.77)_a$
biology	10.50 $(2.92)_a$	11.26 $(2.75)_b$*	10.87 $(2.87)_b$

*$p < .05$, **$p < .01$, ***$p < .001$, for differences between genders.
Note: Within each variable and gender, values with differing subscripts differ at the $p<.01$ level on Scheffe post hoc analyses.

Students indicated that most of the people who were important to them thought they should enroll in physics, chemistry, and biology classes in high school, but significant differences in subjective norms were found among the three subject areas in a repeated measures ANOVA, $\underline{F}(2,1348) = 26.87$, $\underline{MSE} = .63$, $p < .001$. Scheffe post hoc analyses indicated that students perceived more support for biology enrollment than for physics or chemistry enrollment, $\underline{F}(2,1348) = 42.36$, $\underline{MSE} = .63$, P , $< .01$, and $\underline{F}(2,1348) = 17.97$, $\underline{MSE} = .63$, $p < .01$, respectively.

Gender by science subject interactions were found for intent, $\underline{F}(2,1330) = 7.45$, $\underline{MSE} = .39$, $\underline{p} < .001$; attitude, $\underline{F}(2,1322) = 6.65$, $\underline{MSE} = .96$, $p < .001$; and subjective norms, $\underline{F}(2,1322) = 5.66$, $\underline{MSE} = .81$, $\underline{p} < .004$. Females were as inclined as males to indicate intent to take physics or chemistry but were more inclined to indicate that they intended to take biology. Males indicated as positive an attitude as females toward enrollment in physics and chemistry, but females indicated a more positive attitude toward biology enrollment. Females were more likely than males to indicate that other people were encouraging of their enrollment in biology.

Differences among school samples in means of model variables and external variables were examined. One way ANOVAs indicated significant differences at the $\underline{p} < .001$ level among schools in intent to enroll in chemistry and biology classes, $\underline{F}\ (4,676) = 8.21$, $\underline{MSE} = 2.77$; $\underline{F}\ (4,676) = 10.94$, $\underline{MSE} = 2.42$, respectively; attitude toward chemistry and biology enrollment, $\underline{F}\ (1,675) = 4.64$, $\underline{MSE} = 2.82$; $\underline{F}\ (4,677) = 10.05$, $\underline{MSE} = 2.90$, respectively, subjective norms in biology, $\underline{F}\ (4,675) = 6.12$, $\underline{MSE} = 2.12$, self-efficacy in chemistry and biology, $\underline{F}(4,673) = 8.19$, $\underline{MSE} = 7.35$; $\underline{F}(4,672) = 5.91$, $\underline{MSE} = 7.94$, respectively. Gender by school ANOVAs indicated significant school differences in total epistemological beliefs, belief in fixed ability and belief in quick learning, $\underline{F}\ (3,307) =$

12.98, MSE = 166.21; F (3,307) = 12.39, MSE = .49; F (3,307) = 7.54, MSE = .88, respectively. Scheffe post hoc analyses indicated that the majority of the school differences occurred because students in the urban school indicated greater intent to enroll in science courses, a more positive attitude toward science, more sophisticated epistemological beliefs, and a higher science self-efficacy than did students in other districts. Students in the urban district may been different from students in other districts because during the week before completion of the questionnaire, they had considered their class schedules for the next three years under the guidance of their science teacher who impressed upon them the importance of taking as many science courses as possible. Further analyses were conducted with school included as an independent variable, but when no school differences are found results reported are those for the combined schools.

Tests of Hypotheses

Hypothesis 1: Prediction of intent from attitude and subjective norm components. The Ajzen and Fishbein (1980) model states that the intent to perform a behavior will be predicted by attitude toward the behavior and the subjective norms associated with the behavior. As expected, attitude toward enrollment and subjective norm components correlated significantly with intent to enroll in each of the science subject areas. Correlations between intent, attitude, and subjective norms components are listed in Table 2. Correlations between components and intent were higher for the urban school than for the remainder of the other schools combined.

It was hypothesized that students' intent to enroll in high school physics classes would be predicted by their attitude toward physics class enrollment and their indication of the degree of support of others for participation in a physics class. Likewise, intended participation in chemistry classes should be predicted by attitude toward chemistry

Table 2. Correlations Between Attitude Toward Behavior, Subjective Norms, and Intent to Enroll in Science Classes for Physics, Chemistry, and Biology (N=678)

Subject	2 Urban	2 Other	2 Total	3 Urban	3 Other	3 Total
Physics						
1. Attitude toward enrollment	.58	.44	.46	.79	.64[a]	.66
2. Subjective norms				.53	.46	.47
3. Intent to enroll						
Chemistry						
1. Attitude toward enrollment	.31	.47	.45	.80	.67[a]	.69
2. Subjective norms				.38	.55	.53
3. Intent to enroll						
Biology						
1. Attitude toward enrollment	.55	.48	.49	.76	.61[a]	.63
2. Subjective norms				.45	.48	.48
3. Intent to enroll						

All correlations were significant at the $p<.01$ level.
[a] Correlations for urban district and other districts differ at the $p<.01$ level of significance.

enrollment and support of others for chemistry enrollment, and intent to enroll in high school biology should be predicted by its corresponding attitude and subjective norms components. These hypotheses were tested by hierarchical regression analyses, using the model $BI = w_1AB + w_2SN$ in the first step and entering the interaction term, $w_3(AB*SN)$, in the second step.[1] Tables 3, 4, and 5 summarize the regression analyses. When school group (urban versus other) was included in later analyses as an external variable, it was not a significant predictor of intent in any of the subject areas; so regression analyses are presented for all schools combined.

The first hypothesis was supported by results of regression analyses for each of the subject areas. Attitude and subjective norm components predicted intent to enroll in

Table 3. Summary of Regression Analyses for Prediction of Physics Class Enrollment Intentions from Attitude toward Behavior, Subjective Norms, and Interaction Components for Combined Groups (N=618)

Variable	B	SE B	ß	F	ΔR^2
Step 1				292.49***	.49***
Physics attitude	.56	.03	.58	316.46***	
Physics subjective norm	.20	.03	.21	40.1***	
Step 2				292.49***	.00
Physics attitude	.56	.03	.57	309.12***	
Physics subjective norm	.20	.03	.21	39.97***	
Physics attitude x physics subjective norm	-.05	.03	-.05	3.42	
Step 3				87.61***	.04***
Physics enrollment attitude	.47	.03	.48	202.79***	
Physics subjective norms	.14	.03	.15	21.51***	
Physics enrollment attitude x physics subjective norms	-.06	.03	-.06	5.04	
Physics self-efficacy	.20	.03	.20	35.18***	
General academic ability	.09	.03	.09	9.60	
Gender	-.09	.06	-.05	2.54	
Career goal group	-.09	.10	-.03	.96	
School group	-.13	.08	-.05	2.76	

***$p<.001$.

Note: Step 1: Attitude toward enrollment and subjective norms were entered simultaneously.

Step 2: Attitude x subjective norm interaction term is entered into the prediction equation after the variance accounted for by attitude and subjective norms terms is removed.

Step 3: External variables are entered simultaneously after variance in intent accounted for by attitude, subjective norms, and attitude x subjective norms interaction is removed.

Table 4. Summary of Regression Analyses for Prediction of Chemistry Class Enrollment Intentions from Attitude toward Behavior, Subjective Norms, and Interaction Components for Combined Groups (N=617)

Variable	B	SE B	ß	F	ΔR²
Step 1				322.15***	.52***
Chemistry attitude	.54	.03	.56	326.43***	
Chemistry subjective norm	.26	.03	.27	75.72***	
Step 2				245.48***	.03***
Chemistry attitude	.53	.03	.54	319.41***	
Chemistry subjective norm	.26	.03	.25	70.19***	
Chemistry attitude x chemistry subjective norm	-.14	.02	-.16	35.20***	
Step 3				121.92***	.04***
Chemistry enrollment attitude	.47	.03	.48	209.24***	
Chemistry subjective norms	.19	.03	.20	42.11***	
Chemistry enrollment attitude x chemistry subjective norms	-.14	.02	-.17	40.73***	
Chemistry self-efficacy	.10	.03	.10	8.78	
General academic ability	.15	.03	.16	32.26***	
Gender	.02	.05	.01	.13	
School group	.04	.07	.01	.31	

***p<.001.

Note: Step 1: Attitude toward enrollment and subjective norms were entered simultaneously.

Step 2: Attitude x subjective norm interaction term is entered into the prediction equation after the variance accounted for by attitude and subjective norms terms is removed.

Step 3: External variables are entered simultaneously after variance in intent accounted for by attitude, subjective norms, and attitude x subjective norms interaction is removed.

Table 5. Summary of Regression Analyses for Prediction of Biology Class Enrollment Intentions from Attitude toward Behavior, Subjective Norms, and Interaction Components for Combined Groups (N=617)

Variable	B	SE B	ß	F	ΔR2
Step 1				222.84***	.42***
Biology attitude	.49	.03	.52	216.94***	
Biology subjective norm	.20	.03	.22	38.75***	
Step 2				158.25***	.02***
Biology attitude	.46	.03	.48	178.13***	
Biology subjective norm	.20	.03	.21	36.48**	
Biology attitude x biology subjective norm	-.11	.03	-.13	17.27***	
Step 3				73.75***	.06***
Biology enrollment attitude	.36	.04	.38	100.56***	
Biology subjective norms	.12	.03	.12	12.62***	
Biology enrollment attitude x biology subjective norms	-.11	.03	-.13	18.01***	
Biology self-efficacy	.20	.04	.21	31.93***	
General academic ability	.09	.03	.10	10.67***	
Gender	.13	.05	.07	5.35	
School group	.08	.08	.03	1.14	

***$p < .001$.

Note: Step 1: Attitude toward enrollment and subjective norms were entered simultaneously.

Step 2: Attitude x subjective norm interaction term is entered into the prediction equation after the variance accounted for by attitude and subjective norms terms is removed.

Step 3: External variables are entered simultaneously after variance in intent accounted for by attitude, subjective norms, and attitude x subjective norms interaction is removed.

physics, chemistry, and biology classes and the interaction term accounted for a small but statistically significant amount of additional variance in intent to enroll in biology and chemistry classes. Students with more positive attitudes toward enrollment and those who perceived more social support for enrollment were more likely to indicate that they intended to enroll in a class. For biology and chemistry enrollment intentions, attitude was a better predictor for students with low subjective norms ratings than for those with high subjective norms ratings. ANOVA tables for the three-predictor regression analyses are presented in Table A3-Appendix A.

Hypothesis 2: Role of external variables in prediction of intent to enroll. If external variables act only through their effects on attitude or subjective norms, then no significant additional variance should be explained by external variables after the variance explained by the internal variables is removed. In order to test this hypothesis, a third step in the hierarchical regression analyses reported in Tables 3, 4, and 5 was conducted for each subject area. Attitude toward behavior, subjective norms, and an attitude x subjective norm interaction variable were entered into the equation for prediction of intent to enroll in Step 1 and Step 2. Five external variables including gender, general academic ability, subject-area self-efficacy, school group (urban versus rural), and career goals were then added to the equation in Step 3, so that the model tested was $BI = w_1AB + w_2SN + w_3AB{*}SN + w_4\text{Gender} + w_5\text{Ability} + w_6\text{Self-efficacy} + w_7\text{Career goal} + w_8\text{School group}$.[2]

Although the addition of external variables to the prediction of intent resulted in a significant increase in the proportion of variance explained, the increase was small for each science subject area, ranging from 4% in physics and chemistry to 6% in biology. Self-efficacy beliefs added significantly to the prediction of physics and biology intent and general academic ability contributed to prediction of chemistry and biology intent. Students with high self-efficacy beliefs were more likely than those with low self-efficacy beliefs to indicate that they intended to enroll in physics and biology. Students with high ability were more inclined than those with lower ability to indicate that they intended to enroll in chemistry or biology. ANOVA tables for the third step of the regression analyses are presented in Table A4 - Appendix A.

Hypothesis 3: Gender differences in relative contributions of attitude and subjective norms components in prediction of intent to enroll in physics, chemistry, or biology. It was predicted that attitude toward enrollment would be a stronger influence than subjective norms on enrollment intent for both male and female participants, and that the subjective norm component would be more influential for females than for males. As shown in Table 6, attitude was the more influential component in prediction of intent for males and females in each science area, as predicted. Students with more positive attitudes toward enrollment were more inclined to indicate that they intended to enroll.

Although there were gender differences in the significance of the subjective norm component in the prediction of physics and biology intent and in the value of the AB*SN interaction to prediction of physics intent, t-tests for differences in beta coefficients showed no significant gender differences. Table 6 displays the ß coefficients obtained for male and female students and the t-values obtained for comparison of male and female ß coefficients.

Hypothesis 4: Effects of external variables on contributions of attitude and subjective norms to prediction of intent. The Theory of Reasoned Action states that external variables may affect intent to perform a behavior through effects on the relative contributions of attitude and subjective norms components to intent. Six external variables, including gender, general academic ability, physics self-efficacy, career goals, school group (urban

Table 6. Beta Coefficients obtained for Male and Female Participants for Attitude toward Behavior and Subjective Norms Components in the Three-Predictor Models for Physics, Biology, and Chemistry

Science subject	Component	Gender	ß	t
Physics	Attitude toward behavior	Male	.66***	
		Female	.61***	.06
	Subjective norms	Male	.12	
		Female	.23***	1.38
	AB*SN	Male	-.04	
		Female	-.14**	1.25
Chemistry	Attitude toward behavior	Male	.61***	
		Female	.60***	.13
	Subjective norms	Male	.18**	
		Female	.24***	-.06
	AB*SN	Male	-.15*	
		Female	-.14**	.13
Biology	Attitude toward behavior	Male	.54***	
		Female	.61***	-.88
	Subjective norms	Male	.22*	
		Female	.11	1.38
	AB*SN	Male	-.08	
		Female	.06	-1.75

*$p<.05$, **$p<.01$, ***$p<.001$.

versus other) and personal epistemological beliefs were tested for interactions with attitude and subjective norms components in the prediction of enrollment intent in physics. The fourth hypothesis was tested by constructing separate regression models for each external variable. For each model, attitude, subjective norms, and their interaction term were entered in the first two steps, followed by terms representing the interaction between attitude, subjective norms, their interaction, and the external variable. For example, in order to test the effect of ability on the contributions of attitude and subjective norms to prediction of intent, the following model was tested in the third step: $BI = w_1AB + w_2SN + w_3AB*SN + w_4AB*Ability + w_5SN*Ability + w_6(AB*SN)*Ability$. Career goal was coded 1 if students planned to enter an engineering or physical science career, or 0 if they did not plan a career in physical science or engineering. Results of the regression analyses indicated that prediction of intent improves significantly when gender by internal variable interaction terms are added to the model, although the additional variance explained by the interaction terms was only 1% of the total. The regression analysis conducted with gender interaction terms is summarized in Table 7. Additional explained variance was primarily due to the three-way interaction between gender, attitude and subjective norms. When separate regression analyses were conducted for male and female participants, the attitude by subjective norm interaction term predicted intent for female participants ($\beta = -.14$), $F = 7.83$, $p < .01$, but not for male participants ($\beta = -.04$), $F = .43$, $p < .51$ (see Table 6). Among females whose attitude toward physics was less positive, those with high perceived social support for physics enrollment were more likely than those with low perceived social support to indicate that they intended to enroll. Among females whose attitude toward physics enrollment was more positive, perceived social support made almost no difference in enrollment intent, with both groups strongly indicating that they

Table 7. Summary of Regression Analyses with Inclusion of Internal and Gender Interaction Terms in the Prediction of Physics Intent (N = 676).

Variable	B	SE B	ß	F	ΔR^2
Step 1				296.82	.46***
Attitude toward physics (AB)	.56	.03	.56	314.49***	
Physics subjective norm (SN)	.21	.03	.21	44.86***	
Step 2				200.65***	.00
Attitude toward physics	.56	.03	.55	305.38***	
Physics subjective norm	.21	.03	.21	44.73***	
AB x SN	-.06	.03	-.06	4.88	
Step 3				104.05***	.01**
AB	.47	.10	.47	23.09***	
SN	.07	.10	.07	.51	
AB x SN	.11	.07	.12	2.28	
Gender x AB	.06	.06	.09	.84	
Gender x SN	.10	.06	.15	2.31	
Gender x (AB x SN)	-.12	.04	-.20	6.28**	

***p<.001.

intended to enroll. No interaction between attitude and subjective norms was observed for males, for whom both high subjective norms scores and positive attitude scores predicted enrollment intent.

No significant improvement of prediction was observed when school group, academic ability, physics self-efficacy, epistemological beliefs, or career goal interactions were added to the model. Regression analyses conducted with ability, self-efficacy, epistemological belief, career goal, and school group are summarized in Table A5 - A9 in Appendix A. Table A10 -Appendix A contains an ANOVA table for regression analyses with the external variable x internal variable interaction terms.

Hypothesis 5: Effects of external variables on determinants of attitude and subjective norms components. Attitude determinant items are used to investigate the beliefs that underlie student attitudes toward enrollment in physics classes. An attitude determinant score is the product of an outcome belief and its corresponding evaluation and may be interpreted as an indication of the positive influence of the determinant on the decision to enroll in a high school physics course. Before interpreting differences in beliefs, it is necessary to demonstrate that the beliefs measured are an accurate and reasonably complete description of those underlying the attitude and subjective norms components. If the attitude determinants provide an accurate and reasonably complete description of the beliefs that underlie attitude toward enrollment, the relationship between attitude determinants and the attitude toward behavior item may be described as : $AB = \Sigma(b)(e)$, where $(b)(e)$ is a determinant of attitude. The summed attitude determinant scores were correlated with scores on the attitude toward behavior item, $r=.60$, $p<.01$, and with intent to enroll in a high school physics class, $r=.57$, $p<.01$. The correlation between summed attitude determinant scores and intent was similar to that obtained between the attitude item and intent, $r=.66$. Means for attitude belief items are listed in Table A11 -Appendix A. Attitude and subjective norms determinant means and standard deviations are presented in Table A13 - Appendix A.

Subjective norms determinants were calculated by multiplying each normative belief with its corresponding motivation to comply rating. Means for subjective norms belief items are listed in Table A12 - Appendix A. The relationship between subjective norms determinants and the subjective norms item is described as: $SN = \Sigma(nb)(mc)$. As predicted by the model, the summed subjective norms determinants were significantly correlated with scores on the subjective norms item concerning enrollment in physics, $r=.47$, $p<.01$, and with intent to enroll in a high school physics class, $r=.46$, $p<.01$. The correlation between summed subjective norm determinants and intent was similar to that obtained for the subjective norm item and intent, $r=.47$.

The Theory of Reasoned Action states that attitude and subjective norms beliefs are the best predictors of behavioral intent. According to Fishbein and Ajzen (1980, p. 90), assessing the underlying beliefs may help in understanding the basis for the intention, but because their effects operate through the attitude and subjective norms components, they make no independent contribution to prediction of intent. This assumption of the Fishbein and Ajzen theory was tested for prediction of physics enrollment intent by conducting hierarchical regression analysis, first using the model $BI = w_1AB + w_2SN + w_3(AB^* SN)$, and adding the summed attitude and subjective norms determinants with their interaction term to the prediction equation in the third step. Contrary to the Fishbein and Ajzen model, the sum of the attitude determinants and the sum of the subjective norms determinants predicted significant additional variance in enrollment intent, F change = 14.39, $MSE = .48$, $p<.001$; $\Delta R^2 = .03$. Thus, this assumption of the Fishbein and Ajzen model was not strongly supported. The summed attitude determinants added significantly to the prediction of intent, $F = 20.78$, $p < .001$, so it is possible that the attitude toward enrollment item and the determinants of attitude items are measuring somewhat different constructs.

Forty-one students in only two districts were sampled in the preliminary questionnaire that was used to determine salient beliefs listed in the final questionnaire. It was possible that the salient beliefs identified might be more highly correlated with attitude and subjective norms items for the sampled groups than for groups that did not complete the preliminary questionnaire. To investigate this possibility, one way ANOVAs with school (preliminary questionnaire versus no preliminary questionnaire) as the independent variable were conducted for each determinant. A significant difference between groups was found for school counselor influence, F (1,662) = 8.769, MSE = 153.766, $p < .01$. Students from districts that had not been sampled for the preliminary questionnaire reported being more influenced by their school counselor than those from districts who were sampled (non-preliminary questionnaire districts M = 24.58, SD = 12.74; preliminary questionnaire districts M = 21.68, SD = 12.12). Correlations between summed attitude determinant scores and the attitude toward physics enrollment item did not differ significantly for the non-sampled districts and those that were sampled with the preliminary questionnaire, $r = .63$ and $r = .57$, respectively. The correlation between summed subjective norms determinants and the subjective norms item did not differ significantly for the non-sampled districts and those that were sampled, $r = .52$ and $r = .43$, respectively.

To evaluate the effects of external variables on the individual determinants of student attitudes and subjective norms, multiple regression analyses were conducted with each determinant regressed on gender, science self-efficacy, ability, and school group (urban versus other).[3] Summaries of the regression analysis are presented in Tables A16-A31 in Appendix A. Table 8 presents a summary of the effects of external variables on attitude and subjective norms determinants for intent to enroll in physics. The effect of an external variable on a determinant is listed if significant at $p < .001$. The hypothesis that the importance of determinants of attitude and subjective norms components would depend on external variables was supported for physics self-efficacy, general academic ability, career goals and gender.

Students with high physics self-efficacy scores were more likely than those with low self-efficacy scores to be positively influenced by all attitude determinants considered. They were more likely to believe that taking physics was useful, that it would help them get into a good college and allow them to take advanced courses when they were in college, that physics would be fun, and that it would help with their future occupations. They were less deterred by beliefs that physics might be a lot of work or might require a lot of extra time. In general, high self-efficacy students were less concerned than others that taking physics might decrease their grade point averages. However, a significant self-efficacy by ability interaction effect was found for beliefs about the effect of physics on grade point average. Students with high self-efficacy ratings were less concerned than those with low self-efficacy ratings about the effect of taking physics on their grade point averages only if they also had high academic ability. High ability students with low ratings on physics self-efficacy were just as concerned as low ability students about the possible negative effects of physics on their grade point averages.

Not surprisingly, students whose career goal was physics or engineering were inclined to be more influenced than others by the belief that taking physics would help them in their future occupations. Students who were high in general academic ability were

Table 8. Summary of Attitude and Subjective Norms Determinants for Enrollment in Physics by External Variable (Epistemological beliefs N=314. Others N = 617).

Determinant	Gender	Physics Self-efficacy	Ability	Epistemological Beliefs	Career
Taking high school physics will:					
help me learn concepts useful in everyday life.		High>Low	High>Low		
cause me to work hard.	Female>Male	High>Low			
allow me to take advance courses in college.		High>Low	High>Low	Sophis>Naive	
be a lot of fun.		High>Low			
help me in my future occupation.		High>Low			Physics>Other
require a lot of extra time.		High> Low			
not decrease my GPA.		High> Low		Sophis>Naive	
help me get into a good college.		High>Low	High>Low		
People who think I should enroll in high school physics:					
science teacher		High>Low			
good friends		High>Low			
college admissions officer		High>Low			
mother		High>Low			
sibling		High>Low			
boyfriend/girlfriend		High>Low			
high school counselor		High>Low	High>Low		
father		High>Low			

Note: "External Variable" is a spanning header over Gender through Career.

more inclined than others to be positively influenced by the beliefs that physics would help them get into a good college and would allow them to take advanced courses in college. Students high in academic ability were also more inclined to indicate a positive influence of the usefulness of physics in everyday life, but the effect of ability was moderated by gender (see Table A16). Males who were high in ability were more inclined than those who were low in ability to believe that physics would be useful. Ability had no influence on beliefs about the usefulness of physics for female students. Females were less likely than males to be concerned that taking physics would result in a lot of unwanted hard work.

Students who rated high in physics self-efficacy indicated more positive influence for physics enrollment from all people or groups included in the subjective norms determinants than did students who rated low in physics self-efficacy. Students with high academic ability were more inclined than those with low academic ability to indicate a positive influence on enrollment by their high school counselor. Students from the urban district were more inclined than others to be positively influenced by their science teacher. The latter result is not surprising because of the science enrollment advice given this group of students by their science teacher the week before the questionnaire was administered.

Hypothesis 6: Gender differences in physics, chemistry, and biology self-efficacy. It was hypothesized that male and female student self-efficacy beliefs would not differ for biology and chemistry, but that males would indicate greater self-efficacy than females in physics. Results did not support this hypothesis. As described in Table 1, no gender difference was found for physics self-efficacy (Male mean = 10.35, SD = 2.87; Female mean = 10.66, SD = 2.61; F = .143, MSE = 6.38, ns) nor was a gender difference found for chemistry self-efficacy (Male mean = 10.34, SD = 2.86; Female mean =

Table 9. Subject Area Success Expectancies and Perceived Value Item Means and Standard Deviations by Gender (N=678)

Variable	Mean (Standard Deviation) Males		Females		Total	
Expectations for success						
physics	5.23	$(1.66)_a$	5.36	$(1.50)_a$	5.29	$(1.59)_a$
chemistry	5.29	$(1.61)_{ab}$	5.32	$(1.44)_a$	5.30	$(1.53)_a$
biology	5.45	$(1.60)_b$	5.73	$(1.42)_b$ *	5.58	$(1.52)_b$
Perceived value of taking course						
physics	5.12	$(1.66)_a$	5.30	$(1.59)_a$	5.17	$(1.63)_a$
chemistry	5.05	$(1.66)_a$	5.30	$(1.59)_a$*	5.17	$(1.63)_a$
biology	5.04	$(1.74)_a$	5.53	$(1.59)_b$**	5.28	$(1.68)_a$

*$p < .05$, **$p < .01$, ***$p < .001$, for differences between genders.
Note: Within each variable and gender, values with differing subscripts differ at the $p < .01$ level on Scheffe post hoc analyses.

10.62, SD = 2.66; $F = .02$, MSE = 6.15, ns). Females indicated a higher biology self-efficacy than did males (Male mean = 10.49, SD = 2.91; Female mean = 11.26, SD = 2.75); $F = 5.57$, MSE = 6.68, $p < .05$.

Separate ANOVAs were conducted for subject area self-efficacy for males and females. The analyses revealed that for males, subject area self-efficacy beliefs did not differ, $F(2,343) = 1.37$, MSE = 2.25, ns. Significant differences among subjects in self-efficacy were found for female students, $F(2,323) = 21.14$, MSE = 1.93, $p < .001$. Scheffe post hoc analyses indicated that females had higher self-efficacy in biology than in physics or chemistry, $F(2,323) = 29.31$, MSE = 1.93, $p < .01$, and $F(2,323) = 33.74$, MSE = 1.93, $p < .01$, respectively.

Significant subject area by gender interactions were found for ratings of expectations for success, $F(2,1342) = 3.33$, $p < .036$, and for ratings of the value of taking a course in the subject, $F(2,1338) = 4.34$, $p < .013$. Table 9 lists means and standard deviations obtained for ratings of expectation for success and value of success in each subject area. Separate ANOVAs revealed differences in expectations for success among science subject areas for both males and females, $F(2,346) = 5.46$, MSE = .81, $p < .004$, and $F(2,323) = 23.60$, MSE = .70, $p < .001$, respectively. Scheffe post hoc analyses indicated that males expected greater success in biology than in physics, $F(2,346) = 9.93$, MSE = >81, $p < .01$, but that males' expectations for success in chemistry did not differ from expectations in physics or biology, $F(2,346) = .49$, MSE = .81, ns, and $F(2,346) = 5.99$, MSE = .81, ns, respectively. Females expected greater success in biology than in physics or chemistry, $F(2,323) = 31.61$, MSE = .70, $p < .01$, and $F(2,323) = 38.83$, MSE = .70, $p < .01$, respectively, but did not indicate differing expectations between physics and chemistry, $F(2,323) = .37$, MSE = .70, ns.

Separate repeated measures ANOVAs for each gender for perceived valued of success among science subject areas showed no subject area differences for males, $F(2,344) = .56$, MSE = .55, ns. Females, however, indicated significant differences in perceived value of success among the science subject areas, $F(2,323) = 6.70$, MSE = .80, $p < .001$. Scheffe post hoc analysis indicated that females valued success in biology more than success in physics and chemistry, $F(2,323) = 9.92$, MSE = .80, $p < .01$ and $F(2,323) = 10.19$, MSE = .80, $p < .01$. Female participants did not indicate a difference in the perceived value of success for physics and chemistry, $F(2,323) = .002$, MSE = .80, ns.

Hypothesis 7: Gender differences in personal epistemological beliefs. It was predicted that high school females would be less likely than high school males to believe in fixed ability or quick learning and that females would indicate more sophisticated epistemological beliefs overall than would males. Gender by school ANCOVAs, using general academic ability as a covariate, were conducted for total epistemological score and for the fixed ability and quick learning subsets. Results were consistent with those predicted. Female students indicated more sophisticated epistemological beliefs than did males on the total scale (Male mean = 77.11, SD = 12.98, Female mean = 71.04, SD = 14.16), $F = 11.52$, MSE = 151,80, $p < .001$). Females were less likely than males to indicate belief in fixed ability (Male mean = 2.78, SD = .76; Female mean = 2.46, SD = .70), $F = 11.32$, MSE = .46, $p < .001$) or in quick learning (Male mean = 2.90, SD =.95; Female mean = 2.55, SD = .96); $F = 6.67$, MSE = .791, $p < .01$.

Discussion

This study applied the Theory of Reasoned Action to investigation of freshman students' attitudes toward enrollment in nonrequired physics, chemistry, or biology classes during high school. In addition to the investigation of the relationships between attitude, subjective norms, and intent components for the three subject areas, the determinants of attitude and subjective norms components for intent to enroll in physics were investigated. The effects of five external variables, including student gender, academic ability, science self-efficacy, personal epistemological beliefs, and career goals were considered.

Why do fewer students enroll in high school physics than in chemistry or biology? Analyses of subject area differences in intent, attitude, and subjective norms indicate that even though these freshmen indicate that they are likely to enroll in classes in all three science subject areas, fewer students intend to enroll in physics than in chemistry or biology classes. Students are less convinced that the outcomes of enrollment in physics will be positive. They think that others are more supportive of biology class enrollment than of physics and chemistry enrollment. Thus, the differences among science subject areas found in enrollment intent are related both to students' own beliefs about whether the outcomes of course enrollment will be positive or negative and to their beliefs about social support for enrollment in each area.

Why do a larger proportion of females than males intend to enroll in biology, yet a smaller proportion of females than males intend to enroll in physics? Surprisingly, female students indicated that their attitudes and the support they received from others for physics enrollment were as positive as that of male students. Females were as inclined as males to indicate that they intended to enroll in a high school physics class. But gender differences were found in perception of support of others and in feelings of self-efficacy among the science subject areas. Male participants felt equal social support for enrollment in all the science subjects considered, but female participants indicated stronger social support for biology enrollment than for physics or chemistry enrollment. Females expected to be more successful in biology than in chemistry or physics and they valued success in biology more than success in the other science subjects. Male participants valued success in all science areas equally.

Support was found for hypotheses based on the Fishbein and Ajzen (1975) model. Attitude toward enrollment, subjective norms, and their interaction term predicted intent to enroll in non required physics, chemistry, and biology classes in high school. Hierarchical regression analyses reported in Tables 3, 4, and 5 indicated that the three-predictor model explained over half of the variance in enrollment intent. The amount of variance explained was somewhat greater than that usually explained when the model is applied with participants under 20 years of age, and was greater than the variance explained in previous studies applying the model to high school science course enrollment (Koballa, 1988; Crawley, 1990). Consistent with the results of Koballa (1988), there was a marked tendency for attitude toward enrollment to be a better predictor of intent to enroll than was the subjective norm component. This result is also consistent with the findings of van den Putte, who concluded on the basis of his meta-analysis that behaviors with large personal relevance, such as studying, were largely influenced by attitude.

The interaction between attitude toward enrollment and subjective norms was a significant predictor of intent to enroll in chemistry and biology classes, but was not significant for physics. Negative ß coefficients were obtained for the interaction terms in chemistry and biology. When attitude toward chemistry enrollment was less positive, the perceived influence of others was a better predictor of enrollment intent. When the subjective norms component was less positive, the attitude component assumed greater influence in the prediction equation. The additional variance in intent explained by the interaction term was quite small: 3% in chemistry and 2% in biology. Although this result suggests that the interaction term should be included in future research, its practical significance in this case was minimal.

The second hypothesis related to the Fishbein and Ajzen model tested in this study was that the variables of gender, academic ability, science self-efficacy, epistemological beliefs, and career goals are external to the model and can only affect intent through their influence on beta coefficients or on the variables that determine attitude and subjective norm components. The results of hierarchical regression analyses described in Tables 3, 4, and 5, in which the external variables are added to the prediction equation after attitude, subjective norms, and their interaction term, do not support this hypothesis. Adding external variables to the original three-predictor regression equation resulted in a significant increase in explained variance in intent to enroll in physics, chemistry, and biology. The additional explained variance was small however, ranging from 4% in physics and chemistry to 7% in biology. These results differ from those of Crawley and

Coe (1990) who found no significant effect when sex, ethnicity, science ability and general ability were added to the prediction model, and from the results of Koballa (1988) who found no relationship between ability group, science grades, and physics enrollment intent. The primary reason for this difference in the effects of external variables is in the addition of self-efficacy beliefs. Subject area self-efficacy beliefs were significant predictors of enrollment intent even when the influence of attitudes and subjective norms was removed. Although the addition of external variables to the model explained significant additional variance in intent, the increase was small enough to not be of much practical significance.

It was predicted that the attitude component would be more important for male and female participants: Students of either gender would place more emphasis on their own beliefs about outcomes of course enrollment than they would place on the wishes of others. When separate three-predictor regression analyses for males and females were conducted for physics, chemistry, and biology intent in the current study, the attitude component was a better predictor than the subjective norms component of intent to enroll in physics, chemistry, or biology by males or females. Students of both genders apparently attach more importance to their own feelings about the behavior than they do to the wishes of other people or groups. For physics, attitude was the only significant predictor for males, consistent with the results obtained by Crawley and Coe (1990). Crawley and Coe found that for male middle school students, attitude was the only predictor of intent to enroll in a high school science class.

It was predicted that female students would be more influenced by the wishes of others than were males students. This prediction was based on the results of Crawley and Coe (1990) who concluded that, in the prediction of high school science enrollment intent, the subjective norm component was the stronger of the two predictors for middle school females. Although separate regression analyses in the current study resulted in differences in prediction of biology and physics intent from the subjective norm component for males and females, the differences in beta coefficients were not found to be significant. The only evidence found in this study for an effect of gender on prediction of intent from attitude and subjective norm is found in the regression analysis summarized in Table 7. When the gender by model component interaction terms were considered in the prediction of physics enrollment intent, the three-way attitude x subjective norm x gender interaction was significant, though it explained only 1% of the variance in intent after the main effects of attitude and subjective norm were removed. Females with less positive attitudes toward enrollment still tended to indicate high enrollment intent if they thought other people were supportive. No differences in prediction of intent by subjective norm was found for males with high or low attitudes.

As discussed above and indicated in the results of the hierarchical regression analyses described in Table 6, student gender had a small but significant effect on the way that physics intent was predicted by attitude and subjective norms. Epistemological beliefs, science self-efficacy, academic ability, and career goals did not interact with attitude or subjective norms components. Gender explained significant additional variance because of its interaction with the attitude x subjective norms interaction component.

The Fishbein and Ajzen model is particularly useful in the study of enrollment intent because it allows investigation of the beliefs than underlie science enrollment attitudes and subjective norms. When student beliefs are known, accurate and positive beliefs can be reinforced, and less positive beliefs can be modified with additional information and experience. If educators want to encourage more students to enroll in high school physics classes, it should be helpful to understand the beliefs that lead to enrollment decisions, and how those beliefs may differ for different groups of students. The utility of focusing on identified beliefs in order to produce attitude and behavior change has been demonstrated by Fishbein, Ajzen, and McArdle (1980), who demonstrated change in alcoholics' beliefs and subsequent behavior concerning enrollment in a treatment program. Crawley and Koballa (1992) found that high school students who listened to a persuasive message about chemistry class enrollment based on beliefs identified using the Fishbein and Ajzen (1975) model had more favorable attitudes than controls toward chemistry enrollment. Actual course enrollment exceeded expected proportions in a group that received the persuasive message, but not in the control group.

What are the important determinants of attitude toward high school physics enrollment? For this sample of high school freshmen, the strongest positive influences among those studied were the belief that taking physics would allow them to take advanced courses in college and would help them get into a good college. Surprisingly, students were not deterred from intended physics enrollment by the belief that taking the class would cause them to work hard. Males and females indicated that taking a physics class means that they would have to work hard, but both genders indicated that working hard is a good thing.

Some salient student attitude beliefs appear to be a deterrent to physics class enrollment. Freshmen in this sample placed an extremely high value on doing things that are fun, and both male and female students indicated that taking a physics class was not likely to lead to a lot of enjoyment. Students were also deterred by the belief that taking physics would require a lot of extra time that could have been spent on other classes or extracurricular activities. Surprisingly, although students in this sample were concerned about maintaining good grades, they did not believe that taking a physics course would decrease their grade point averages.

What are the important determinants of the subjective norms component for intended physics class enrollment? As described in Table A13-Appendix A, in general, subjective norms determinant scores were not as high as those found on the attitude determinants. Most of the mean scores for determinant items were in the "neutral" range. When the questionnaire was administered, students often commented that they had no idea what the expectations of others were about the student's future science course enrollment. Although the range in subjective determinant scores was smaller than that found for attitude determinant scores, some trends were found. Mothers, fathers, and college admissions officers exert the greatest influence on such decisions. School counselors and science teachers also had an influence on decisions. Science teachers were a stronger influence for students in the urban districts than for other students. Friends and siblings exerted relatively little influence.

How do the determinants differ for male and females, and for students with different levels of self-efficacy, ability, and epistemological beliefs? As described in Table 8, results of regression analyses in which individual determinants were regressed on external variables indicated that students with high physics self-efficacy were more inclined than those with low self-efficacy to believe that taking a physics class would be valuable in the future. They believed that taking physics would help them get into a good college and allow them to take advanced courses once they got there, that physics knowledge would be useful in everyday life and in their future occupation. High self-efficacy students were more inclined low self-efficacy students to indicate that other groups or people expected them to enroll in physics, and they were generally more willing to comply with those wishes.

Epistemological beliefs and gender had relatively little influence on attitude or subjective norms determinants. Students with sophisticated epistemological beliefs were more inclined than others to believe that taking physics would allow them to taking advanced courses in college, and were less concerned that taking physics might lead to a decline in grade point average. Females were less concerned than males about the amount of extra time that a physics class might require. Friends were an influence on course enrollment decisions for girls of low ability, but not for males or for girls of high ability. Ability group had no direct relationship to attitude or subjective norms beliefs, although ability interacted with gender in prediction of the important of friend influence, as noted above.

Limitations and Suggestions for Future Research

The Theory of Reasoned Action states that the extent to which behavioral intent predicts actual behavior depends in part on the consistency of the action, target, and context components during the interval between the measurement of intent and engaging in the behavior. But even if the conditions of the behavior remain the same, intent may change during the time interval, especially for long-range predictions. Actual physics class enrollment would be more difficult to predict than biology and chemistry enrollment, because it is a course that is usually taken during the last year of high school, leaving two full years between measurement of intent and the actual course enrollment decision. Beliefs may be modified in many ways during that two-year interval. Freshman students will gain knowledge and experience in other science subjects, and their enjoyment and their success or failure in those subjects may alter their beliefs. Students will make choices about their future careers over the next two years, and are likely to receive advice from parents, school counselors, and college admissions advisors. It is quite likely that students' intentions of science class enrollment will change. Most male students in this sample indicated that they intended to enroll in a high school physics class, with 62% responding that it was at least probable that they would enroll and over 27% of those indicating that enrollment was highly likely. An even greater percentage of female students indicated that they planned to enroll in high school physics, with almost 64% indicating they would probably enroll, and 24% of those indicating that it was highly likely. Nationally, only 15% of males and 12% of females take high school physics. The proportion of students actually taking physics may be somewhat higher for students in this sample, but is not likely to approach the proportion that expressed intent. A rough estimate suggests that between 14% and 39% of all students in these schools actually take physics, and that 12% to 27% of female students take physics. Obviously, many of these freshman students are likely to experience a modification in intent to enroll in physics during the next two years.

There are several possible explanations for the difference between the intent of these freshmen to enroll in high school physics classes and the projected actual enrollment. One explanation, noted above, is simply that intent will decrease for a variety of reasons during the two-year interval before these students actually enroll in physics. A longitudinal study of intent would be useful for documenting any changes in intent, attitude, subjective norm, and beliefs between the freshman year and actual enrollment.

Positive response bias or demand effects could also explain the unexpectedly high indications of intent. Students may have tended to use the positive end of the scale more than the negative end. Not only did almost 64% of the students indicate intent to enroll in physics, but 73% of the sample indicated intent to enroll in chemistry, much higher than the national average of 40%. Mean attitude and subjective norm ratings also tended to be above the neutral point. However, students apparently did not hesitate to give negative ratings to belief items such as the impact of taking physics on their free time or whether taking physics would be fun. Demand effects could also result in a higher than expected rating of intent, if students felt that it was more socially acceptable to indicate positive attitudes and enrollment intent.

Positive response bias and demand effects could obviously affect the means obtained for scale items and could cause intent, attitude, subjective norm, and self-efficacy to appear more positive than they actually are. These means should be interpreted with caution. However, comparisons between subject areas, and analyses of influence of model variables and external variables on intent would be affected only if response bias or demand effects differed for different groups. Of course, there is no way to obtain information about the influence of response bias or demand effects from the current results.

An additional limitation to this study is the assumption that course enrollment decisions are under complete volitional control of the student. It was assumed that the act of course enrollment was completely voluntary; that students had the available resources and opportunities to engage in the behavior. However, discussions with students after administration of the questionnaire suggested that students felt that their course enrollment choices were limited by time and competing requirements. Many courses are required to meet high school graduation or college admissions standards. For some students, few optional classes may remain. Although students' beliefs about time limitations could have been identified in the ratings of the two attitude belief items dealing with the time requirements of taking physics, other beliefs about volitional control over enrollment may not have been identified. Future studies of high school course enrollment decisions should include the perceived behavioral control component suggested by Ajzen (1991).

Implications

One implication of this study for future research involves the inclusion of the attitude toward behavior x subjective norms interaction term to the model for prediction of intent. The prediction term has not consistently been included in previous research, although it may make a small but significant contribution to prediction, as indicated by its significance in the prediction of physics intent for females in the current study. Another implication for future applications of the Theory of Reasoned Action to enrollment intent is the finding that the summed attitude determinants predicted enrollment intent beyond that predicted by the attitude toward enrollment and subjective norm items. Although the summed attitude determinants explained only an additional 3% of the variance in intent after the effects of attitude and subjective norm were removed, this result violates one of the assumptions of the Fishbein and Ajzen model, which states that attitude and subjective norms beliefs are the best predictors of behavioral intent and that underlying beliefs make no independent contribution to prediction of intent. That attitude beliefs did make an independent contribution to prediction of intent suggests that attitude beliefs items measured a somewhat different construct than did the attitude item. The interpretation of the set of beliefs merely as components of attitude must be made with caution.

Other implications of this study are important for educators. Freshman students indicate that getting into a good college and taking advanced courses once they get to college are important to them, but few students of this age are likely to be aware of college entrance requirements and course requirements. More students may be encouraged to enroll in high school physics if they are made aware of the expectations of the better colleges and universities. Students do not perceive taking physics as an enjoyable activity, and it is important to students of high school age to have fun. Educators should use the information they already have about what students find enjoyable in science classes and incorporate such activities into their classes. Studies such as those of Mason and Kahle (1988) and Martinez (1992) that have investigated the ways that different classroom activities influence male and female students are especially valuable. Emphasis on physical science and physics activities that are engaging to both female and male students is important in the elementary and middle school grades. By the time students are freshmen in high school, they have already decided that physics is not enjoyable.

Students are influenced in enrollment decisions by what they believe to be the wishes of others. The freshman students in this sample often indicated during administration of the questionnaire that they did not know what their parents or teachers would encourage them to do, and was obvious that high school course enrollment is not a frequent topic of discussion in many homes. Yet, students indicated that they generally complied with their parents' wishes and wish the advice of their science teachers. Parents are more likely to encourage high school physics enrollment if they understand the advantages of doing so. Parents should be informed of the advantages to their children of enrolling in high school physics courses and should become involved in planning the students' high school course sequence. Science teachers may exert considerable influence over future course enrollment decisions Although it may have been pure coincidence, the students in this study whose science teacher had talked with them about the importance of taking more science classes the week before the questionnaire was administered indicated higher perceived social support, more positive attitudes, and a greater intent to enroll in physics. Female students, in particular may be more influenced in physics enrollment decisions by the wishes of others. Females who do not believe that the outcomes of taking physics are extremely positive may still enroll in classes if they think others support the behavior.

Footnotes

[1] The majority of students in the sample indicated moderate to strong intent to enroll in high school science classes, so distributions for the dependent variables were not normal. Because this assumption was violated, regression analyses were initially conducted with the intent variable dichotomized (no intent to enroll/ intent to enroll) and again with a log10 transformation of the dependent variable. The results of both analyses were quite similar to those obtained when the 1-7 response scale for intent is used. For ease of interpretation, results of analyses using the 1-7 scale are reported. Variable values were transformed into z-scores before analyses.

[2] Similar regression analyses including epistemological beliefs as an external variable in addition to gender, self-efficacy, academic ability, career goal, and school group, were conducted for the 282 participants who completed the epistemological beliefs scale. Epistemological beliefs was not a significant variable in prediction of physics, chemistry, or biology intent.

[3] Comparable regressions were conducted including epistemological beliefs among the external variables in the regression analysis. Epistemological beliefs was a significant variables in only two of the equations. Sophisticated epistemological beliefs were associated with more positive influence of two attitude determinants: physics would allow advanced college courses, $\underline{F} = 15.68$, $\underline{p} < .001$ and taking physics would not lead to a decrease in grade point average, $\underline{F} = 15.67$, $\underline{p} < .001$. Because epistemological beliefs were significant in only two of the equations, this external variables was eliminated from further analyses of determinants in order to include the participants who had not completed

the epistemological scale. Tables A14 and A15 -Appendix A summarize the regression analyses including epistemological beliefs for these two determinants.

References

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179-211.

Ajzen, I., & Fishbein, M. (1980). Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Costanzo, P.R., & Shaw, M.E. (1966). Conformity as a function of age level. Child Development, 37, 967-975.

Crawley, F.E., & Coe, A.S. (1990). Determinants of middle school students' intention to enroll in a high school science course: An application of the Theory of Reasoned Action. Journal of Research in Science Teaching, 27(5), 461-476.

Crawley, F.E., & Black, C.B. (1992). Causal modeling of secondary science students' intentions to enroll in physics. Journal of Research in Science Teaching, 29(6), 585-599.

Crawley, F.E., & Koballa, T.R. (1992). Hispanic-American students' attitudes toward enrolling in high school chemistry: A study of planned behavior and belief-based change. Hispanic Journal of Behavioral Sciences, 14(4), 469-486.

Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, Mass.: Addison-Wesley.

Fishbein, M., Ajzen, I., & McArdle, J. (1980). Changing the behavior of alcoholics: Effects of persuasive communication. In M. Fishbein & I. Ajzen, Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research, (pp. 217-239). Reading Mass.: Addison-Wesley.

Haselhuhn, C.W., Andre, T., Whigham, M., & Veldhuis, G.H. (1995). Attitudes of middle-school students and their parents about education in physical science, biological science, and mathematics. Paper presented at the annual conference of the American Educational Research Association, San Francisco, CA.

Kahle, J.B., & Meece, J. (1994). Research on gender issues in the classroom. In D. L. Gabel, (Ed.), Handbook of Research in Science Teaching and Learning (pp. 542-557). New York: MacMillan Publishing Co.

Koballa, T.R. (1988). The determinants of female junior high school students' intentions to enroll in elective physical science courses in high school: Testing the applicability of the Theory of Reasoned Action. Journal of Research in Science Teaching, 25(6), 479-492.

Lent, R.W., Brown, S.D., & Larkin, K.C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. Journal of Counseling Psychology, 31(3), 356-362.

Lent, R.W., Brown, S.D., & Larkin, K.C. (1987). Comparison of three theoretically derived variables in predicting career and academic behavior: Self-efficacy, interest congruence, and consequence thinking. Journal of Counseling Psychology, 34(3), 293-298.

Levin, T., Sabar, N., & Libman, A. (1991). Achievements and attitudinal patterns of boys and girls in science. Journal of Research in Science Teaching, 28 (4), 315-328.

Martinez, M.E. (1992). Interest enhancements to science experiments: Interactions with student gender. Journal of Research in Science Teaching, 29(2), 167-177.

Mason, C.L., & Kahle, J.B. (1988). Student attitudes toward science and science-related careers: A program designed to promote a stimulating gender-free learning environment. Journal of Research in Science Teaching, 26(1), 25-39.

Mullis, I.V.S., Dossey, J.A., Campbell, J.R., Gentile, C.A., O'Sullivan, C., & Latham, A.S. (1994). NAEP 1992 Trends in Academic Progress. (National Center for Education Statistics Report No. 23-TR01). Washington DC: US Government Printing Office.

Mullis, I., & Jenkins, L. (1988). The science report card: Elements of risk and recovery. Princeton, NJ; Educational Testing Service.

National Science Foundation. (1988). Women and Minorities in Science and Engineering. (NSF 88-301). Washington, DC: Author.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. Review of Research in Education, 16, 153-222.

Qian, G., & Alvermann. D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. Journal of Educational Psychology, 87(2), in press.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82(3), 498-504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. Journal of Educational Psychology, 85(3), 406-411.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. Educational Psychology Review, 6(4), 293-319.

Schommer, M. (1995). Epistemological Belief Questionnaire, Middle School Version. Unpublished document used with permission of the author.

Schommer, M., & Walker, K. (1994, October). Comparing epistemological beliefs about mathematics and social sciences. Paper presented at the Mid-Western Educational Research Association Annual Meeting, Chicago.

Simpson, R.D., Koballa, T.R., Oliver, J.S., & Crawley, F.E. (1994). Research on the affective dimension of science learning. In D. L. Gabel, (Ed.), Handbook of Research in Science Teaching and Learning (pp. 211-234). New York: MacMillan Publishing Co.

Simpson, R., & Oliver, J. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. Science Education, 74(1), 1-18.

Songer, N., & Linn, M. (1991). How do students' views of science influence knowledge integration? Journal of Research in Science Teaching, 28(9), 761-784.

Tippins, D. (1991). The relationship of science self-efficacy and gender to ninth grade students' intentions to enroll in elective science courses. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, April 1991.

US Department of Education. (1993). Digest of Educational Statistics (NCES93-292). Washington, DC: Author.

van den Putte, Bas. (1993). On the Theory of Reasoned Action. Unpublished doctoral dissertation, University of Amsterdam.

Voss, M. (1995, January 30). Few girls in many physics classes. The Des Moines Register, pp. 1T, 2T.

GENERAL CONCLUSIONS

The attitudes of high school freshmen toward science class enrollment predict their enrollment intentions and attitude appears to be a more important factor than the wishes of parents, teachers, or friends in the decision-making process. However, the reason that the wishes of others seems to have less influence over enrollment choices may be that students do not know what important others want them to do. Most students indicated that they usually complied with the wishes of their parents and teachers, but they did not know whether these people would encourage them to participate in high school biology, chemistry, or physics. Educators who wish to encourage students to enroll in high school science classes might do well to inform both students and parents of the advantages of doing so.

As expected, slightly more female students than male students indicated that they planned to enroll in biology classes, and about the same number of males and females reported intent to enroll in chemistry classes. There was no gender difference in intent to enroll in physics classes, a result that was unexpected, in view of the differing patterns of actual enrollments in these districts.

Students in the sample used for this dissertation were decidedly optimistic about their future education. The majority planned to obtain bachelor's degrees. The majority indicated that they planned to enroll in high school physics, chemistry, and biology, although statistics from previous classes suggests that only about 25% will actually enroll in physics classes. Chances are many students will change their minds about enrollment, especially in physics classes. Assuming that a change in intent follows a change in beliefs, as the Fishbein and Ajzen (1975) model predicts, which beliefs about science enrollment change in the two years between freshman optimism and senior enrollment decisions? In particular, which beliefs change for female students, who as freshmen indicate that they plan to enroll in physics, but change their minds in greater numbers than do the males?

Student self-efficacy in science is an important variable in predicting student beliefs and attitudes toward science class enrollment. The relationship was as predicted, for students who expect to experience success are more likely to participate and persist. Of particular interest in the study included in this dissertation is the relationship between physics self-efficacy and physics enrollment beliefs. Students who expect to succeed in physics classes are also more likely than others to expect to learn useful concepts, to get into good colleges and taking advanced courses once they get there as a result of taking physics. They perceive taking extra time to learn something in a difficult class as a good thing, and they are not concerned about damaging their grade points. Students high in self-efficacy were more likely than those low in self-efficacy to indicate that other people wanted them to take a physics class. Science self-efficacy was a more important variable in this study than was academic ability. Surprisingly, there were few differences among ability groups in beliefs about taking a high school physics class. Science self-efficacy should be included as an external variable in future studies of enrollment intent that use the Fishbein and Ajzen model.

Although Fishbein and Ajzen's (1975) Theory of Reasoned Action had again shown its utility in the investigation of student attitudes and enrollment decisions, some cautions are in order. Most of the studies of science course enrollment intent that have applied the Fishbein and Ajzen model have measured intent, rather than actual behavior, as did the study reported in this dissertation. How well does intent to enroll predict actual enrollment decisions? The question is particularly important in this situation, because of the two-year gap between measurement of intent and the actual behavior. Freshmen have only a vague idea about their post-high school plans and future careers. They know relatively little about what to expect in a high school physics class. As they gain in knowledge and experience, beliefs about physics enrollment, and subsequently, enrollment intent is likely to change.

Reference

Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, Mass.: Addison-Wesley.

APPENDIX A
ADDITIONAL TABLES

Table A1. Characteristics of Participating Schools

School	Community size	Enrollment	Students enrolled in physics 1993/94 Total	% Female
Ankeny	18482	1250	104	32%
South Hamilton	1088	250	9	44
Union Community	3370	425	41	35
Cedar Rapids Jefferson	108751	1596	[a]	30
Jefferson-Scranton	4863	425	25[b]	48

[a] Total physics class enrollment figures for Cedar Rapids Jefferson High school were not available.

[b] Figure reported represents second semester enrollments only. It is possible that some additional students were enrolled in physics during the first semester.

Table A2. Demographic Characteristics of Participating Students

Group	N	Mean Age	Race (%) Caucasian	Asian	Other
Ankeny	338	15.5	90.5%	1.5%	8.0%
Male	176	15.6			
Female	159	15.4			
South Hamilton	63	15.4	87.3	1.6	11.1
Male	40	15.6			
Female	23	15.2			
Union	81	15.6	91.3	1.3	7.4
Male	41	15.7			
Female	39	15.5			
Cedar Rapids-Jefferson	102	15.5	84.3	2.0	13.7
Male	56	15.6			
Female	46	15.4			
Jefferson-Scranton	98	15.5	92.8	2.1	5.1
Male	38	15.7			
Female	60	15.4			

Table A3. Significance Tests of Regressions Effects for Model BI = w1AB + w2SN + w3AB*SN for Intent to Enroll in Physics, Chemistry, and Biology.

Source	SS	df	MS	F	p	R^2
Physics						
Regression	287.03	3	95.68	196.89	.00001	.49
Residual	298.83	615	.49			
Chemistry						
Regression	305.34	3	101.78	245.47	.00001	.55
Residual	254.58	614	.41			
Biology						
Regression	237.18	3	79.06	158.25	.00001	.44
Residual	306.75	614	.50			

Table A4. Significance Test of Regression Effects for Model with Attitude, Subjective Norms, Interaction Term, and External Variables .

Source	SS	df	MS	F(change)	p(change)	ΔR^2
Physics						
Regression	313.24	8	39.16	11.73	.00001	.04
Residual	272.63	610	.45			
Chemistry						
Regression	326.53	7	46.65	13.85	.00001	.04
Residual	233.38	610	.38			
Biology						
Regression	267.66	7	15.27	33.46	.00001	.06
Residual	276.26	609	.45			

Table A5. Summary of Regression Analyses with Inclusion of Internal and Epistemological Belief Interaction Terms in the Prediction of Physics Intent (N = 313)

Variable	B	SE B	ß	F	ΔR^2
Step 1				203.80***	.57***
Attitude toward physics (AB)	.66	.04	.65	217.82***	
Physics subjective norm (SN)	.18	.05	.17	15.56***	
Step 2				137.62***	.00
Attitude toward physics	.64	.05	.63	194.78***	
Physics subjective norm	.19	.05	.18	16.80***	
AB x SN	-.06	.04	-.06	2.85	
Step 3				69.44***	.00
AB	.63	.05	.62	176.37***	
SN	.20	.05	.19	16.49***	
AB x SN	-.09	.04	-.09	4.14	
Epis. beliefs x AB	.01	.04	.01	.03	
Epis. beliefs x SN	-.07	.05	-.01	2.49	
Epis. beliefs x (AB x SN)	-.01	.03	-.28	.12	

***$p < .001$.

Table A6. Summary of Regression Analyses with Inclusion of Internal and Physics Self-efficacy Interaction Terms in the Prediction of Physics Intent (N = 674).

Variable	B	SE B	ß	F	ΔR^2
Step 1				289.56***	.46***
Attitude toward physics (AB)	.55	.03	.56	307.23***	
Physics subjective norm (SN)	.21	.03	.21	43.64***	
Step 2				195.52***	.00
Attitude toward physics	.55	.03	.551	298.44***	
Physics subjective norm	.21	.03	.21	43.60***	

AB x SN	-.05	.03	-.06	4.56	
Step 3				99.28***	.00
AB	.54	.03	.54	269.60***	
SN	.21	.03	.21	39.75***	
AB x SN	-.03	.03	-.03	.77	

Self-eff. x AB	-.06	.03	.07	5.06	
Self-eff x SN	-.01	.03	-.01	.07	
Self-eff x (AB x SN)	-.00	.02	-.00	.01	

***p<.001.

Table A7. Summary of Regression Analyses with Inclusion of Model and Academic Ability Interaction Terms in the Prediction of Physics Intent (N = 629).

Variable	B	SE B	ß	F	ΔR²
Step 1				304.77***	.49***
Attitude toward physics (AB)	.57	.03	.58	330.21***	
Physics subjective norm (SN)	.20	.03	.20	40.61***	
Step 2				205.45***	.00
Attitude toward physics	.57	.03	.58	320.86***	
Physics subjective norm	.20	.03	.20	40.47***	
AB x SN	-.05	.02	-.07	3.94	
Step 3				102.41***	.00
AB	.56	.03	.57	299.11***	
SN	.20	.03	.20	37.55***	
AB x SN	-.04	.02	-.05	3.45	
Ability x AB	.00	.03	.00	.01	
Ability x SN	.00	.03	.00	.00	
Ability x (AB x SN)	.02	.02	.02	.48	

***p<.001.

Table A8. Summary of Regression Analyses with Inclusion of Model and Career Goal Interaction Terms in the Prediction of Physics Intent (N = 677).

Variable	B	SE B	ß	F	ΔR^2
Step 1				301.71***	.47***
Attitude toward physics (AB)	.56	.03	.57	321.66***	
Physics subjective norm (SN)	.21	.03	.21	43.68***	
Step 2				204.10***	.00
Attitude toward physics	.56	.03	.56	194.78***	
Physics subjective norm	.21	.03	.21	43.64***	
AB x SN	-.06	.03	-.06	5.15	
Step 3				103.20***	.00
AB	.57	.03	.57	298.20***	
SN	.21	.03	.21	40.29***	
AB x SN	-.04	.03	-.04	2.21	
Career goal x AB	-.10	.11	-.03	.86	
Career goal x SN	-.04	.11	-.01	.14	
Careeg goal x (AB x SN)	-.13	.07	-.05	3.30	

***p<.001.

Table A9. Summary of Regression Analyses with Inclusion of Model and School Group Interaction Terms in the Prediction of Physics Intent (N = 680).

Variable	B	SE B	ß	F	ΔR^2
Step 1				300.60***	.47***
Attitude toward physics (AB)	.56	.03	.56	319.85***	
Physics subjective norm (SN)	.21	.03	.21	44.27***	
Step 2				203.24***	.00
Attitude toward physics	.56	.03	.56	309.77***	
Physics subjective norm	.21	.03	.21	44.16***	
AB x SN	-.06	.03	-.06	4.99	
Step 3				101.68***	.00
AB	.54	.03	.54	253.29***	
SN	.22	.03	.22	42.23***	
AB x SN	-.05	.03	-.06	3.76	
School group x AB	.10	.09	.04	1.18	
School group x SN	-.08	.10	-.03	.67	
School group x (AB x SN)	-.03	.08	-.01	.14	

***p<.001.

Table A10. Significance Tests of Regression Effects for Model with Attitude, Subjective Norms, Interaction Terms, and External Variable Interactions with Model Variables.

Source	SS	df	MS	F(change)	p(change)	ΔR^2
Gender						
Regression	325.19	6	54.20	4.41	.004	.01
Residual	348.98	676	.52			
Epistemological group						
Regression	193.17	6	32.20	1.11	.35	.00
Residual	142.35	307	.46			
Self-efficacy group						
Regression	314.12	6	52.35	2.08	.10	.00
Residual	352.26	668	.53			
Ability group						
Regression	976.15	6	302.94	.18	.90	.00
Residual	929.79	623	1.49			
Career group						
Regression	323.54	6	53.92	1.68	.17	.00
Residual	350.62	671	.52			
School group						
Regression	323.09	6	53.85	.54	.65	.00
Residual	356.91	674	.53			

Table A11. Attitude toward Physics Enrollment Determinant Item Means and Standard Deviations by Gender

	Mean (Standard Deviation)			
Determinant	Males	Females	F(1,674)	Total
AB1a. Taking physics will help me learn new concepts that will be useful in everyday life.	4.44(1.75)	4.37(1.66)	.39	4.40(1.71)
AB1b Learning useful concepts is good.	6.27(1.36)	6.59(.86)	13.10***	6.43(1.16)
AB2a. Taking physics means that I will have to work hard.	5.10(1.66)	5.50(1.39)	10.54***	5.29(1.54)
AB2b. Working hard is good.	5.42(1.64)	5.84(1.33)	12.41***	5.63(1.52)
AB3a. Taking physics will allow me to take more advanced courses in college.	5.52(1.60)	5.68(1.43)	1.94	5.60(1.53)
AB3b. Taking advanced courses in college is good.	5.71(1.48)	5.82(1.37)	2.68	5.71(1.49)
AB4a. I will get a lot of enjoyment and have a lot of fun taking physics.	3.59(1.81)	3.51(1.67)	.43	3.55(1.74)
AB4b. Enjoying myself and having fun is good.	6.58(1.02)	6.76(.68)	7.33**	6.67(.88)
AB5a. Taking physics will help me in my future occupation.	4.25(1.82)	4.10(1.95)	1.14	4.18(1.89)
AB5b. Doing things that will help with my future occupation is good.	6.37(1.23)	6.76(1.95)	24.05***	6.56(1.02)
AB6a. Taking a physics class will use a lot of time.	4.62(1.70)	4.74(1.54)	.92	4.67(1.63)
AB6b. Spending a lot of time on one class at the expense of others is good.	3.17(1.59)	3.55(1.44)	11.88***	3.35(1.53)
AB7a. Taking a physics class will decrease my GPA (reverse scored)	4.04(1.77)	4.03(1.87)	.00	4.04(1.82)

Table A11. Attitude toward Physics Enrollment Determinant Item Means and Standard Deviations by Gender, continued.

	Mean (Standard Deviation)			
Determinant	Males	Females	F(1,674)	Total
AB7b. Decreasing my GPA is good. (reverse scored)	6.12(1.61)	6.44(1.41)	7.42**	6.28(1.53)
AB8a. Taking physics will help me get into a good college.	4.99(1.60)	5.13(1.47)	1.34	5.05(1.54)
AB8b. Getting into a good college is good.	6.04(1.54)	6.66(.90)	37.03***	6.34(1.31)

Table A12. Gender Differences in Physics Subjective Norm Determinant Items Means and Standard Deviations

	Mean (Standard Deviation)			
Determinant	Males	Females	F(1,674)	Total
SN1a. My science teacher thinks I should enroll in a physics class.	4.94(1.76)	5.04(1.54)	.73	4.99(1.66)
SN1b Generally speaking, I want to do what my science teacher thinks I should do.	3.75(1.88)	4.29(1.64)	14.04***	4.01(1.80)
SN2a. My good friends think I should enroll in a physics class.	3.95(1.61)	4.17(1.40)	4.00*	4.06(1.51)
SN2b. Generally speaking, I want to do what my good friends think I should do.	3.91(1.74)	4.12(1.61)	2.69	4.00(1.68)
SN3a. College admissions officers think I should enroll in a physics class.	4.77(1.50)	4.79(1.28)	.06	4.78(1.40)
SN3b. Generally speaking, I want to do what college admissions officers think I should do.	4.75(1.75)	5.08(1.42)	6.61**	4.91(1.61)
SN4a. My mother thinks I should enroll in a physics class.	4.85(1.51)	4.99(1.49)	1.80	4.91(1.50)
SN4b. Generally speaking, I want to do what my mother thinks I should do.	4.65(1.75)	4.83(1.59)	2.18	4.74(1.67)
SN5a. My brother or sister thinks I should enroll in a physics class.	4.07(1.53)	4.18(1.40)	.88	4.12(1.47)
SN5b. Generally speaking, I want to do what my brother or sister thinks I should do.	3.48(1.83)	3.60(1.67)	.85	3.53(1.76)
SN6a. My boyfriend/girlfriend thinks I should enroll in a physics class.	4.07(1.40)	4.13(1.32)	.20	4.09(1.36)
SN6b. Generally speaking, I want to do what my boyfriend/girlfriend thinks I should do.	4.22(1.76)	4.11(1.58)	.92	4.17(1.65)
SN7a. My high school counselor thinks I should enroll in a physics class.	4.90(1.46)	4.95(1.39)	.52	4.91(1.43)

Table A12. Gender Differences in Physics Subjective Norm Determinant Items Means and Standard Deviations, continued.

	Mean (Standard Deviation)			
Determinant	Males	Females	F(1,674)	Total
SN7b. Generally speaking, I want to do what my high school counselor thinks I should do.	4.29(1.70)	4.64(1.58)	5.93*	4.46(1.66)
SN8a. My father thinks I should enroll in a physics class.	4.85(1.51)	5.00(1.53)	1.67	4.91(1.52)
SN8b. Generally speaking, I want to do what my father thinks I should do.	4.75(1.77)	4.93(1.61)	1.36	4.82(1.70)

Table A13. Gender Differences in Determinants of Physics Attitude toward Behavior and Subjective Norms Component Means and Standard Deviations

	Mean (Standard Deviation)			
Determinant	Males	Females	F(1,673)	Total
AB3. Taking advanced courses in college.	32.47(13.99)	33.98(12.71)	1.72	33.13(13.44)
AB8. Helping get into a good college.	31.11(13.33)	34.57(11.15)	12.83***	32.86(12.35)
AB2. Physics will make me work hard.	28.38(13.25)	32.51(11.72)	17.77***	30.38(12.66)
AB1. Usefulness of physics in everyday life.	28.33(12.97)	29.09(11.98)	.61	28.63(12.59)
AB5. Helpful to future occupation.	27.53(13.26)	27.94(13.87)	.11	27.72(13.57)
AB7. Affect my GPA.	25.35(13.88)	26.11(13.81)	.60	25.73(13.85)
AB4. Having fun.	23.58(12.48)	23.84(11.77)	.03	23.70(12.13)
AB6. Extra time requirement.	14.84(9.71)	16.84(9.27)	8.89**	15.79(9.54)
SN8. Father.	24.11(13.22)	25.60(12.75)	1.54	24.74(13.03)
SN3. College admissions officer	23.81(13.18)	25.06(11.28)	1.50	24.35(12.31)
SN4. Mother	23.49(12.75)	24.82(12.00)	1.93	24.04(12.42)
SN7 School Counselor	21.90(12.44)	24.03(12.41)	3.66	22.88(12.45)
SN1. Science teacher	19.86(13.46)	22.34(12.25)	5.347*	20.99(12.95)
SN6. Boyfriend/girlfriend	18.19(10.57)	17.94(10.14)	.20	18.02(10.36)
SN2. Good friends	16.20(10.93)	17.82(9.86)	3.68	16.93(10.45)
SN5. Brother or sister	15.42(11.38)	16.12(10.59)	2.48	15.65(10.94)

*p < .05, **p < .01, ***p < .001.

Table A14. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Epistemological Beliefs, Physics Self-efficacy, and Ability: Taking Physics Will Allow Me to Take Advanced Courses in College (N = 285).

Variable	B	SE B	ß	F	ΔR^2
Step 1				25.09	.35***
Gender (G)	.05	.10	.03	.26	
School (S)	-.21	.10	-.10	4.02	
Epistemological beliefs (EB)	-.21	.05	-.22	15.68***	
Physics self-efficacy (PSE)	.47	.06	.45	73.75***	
Academic ability (A)	.07	.05	.08	2.04	
Career goal (CG)					
Step 2				8.01	.04
Gender	.05	.12	.03	.16	
School	-.11	.36	-.05	.09	
Epistemological beliefs	-.32	.19	-.33	2.69	
Physics self-efficacy	.47	.21	.46	5.39	
Academic ability	.43	.18	.44	5.86	
Career goal					
G x S	-.10	.22	-.08	.20	
G x EB	.10	.11	.17	.76	
G x PSE	.02	.12	.02	.02	
G x A	-.26	.11	-.41	5.63	
G x CG	-.11	.53	-.04	.05	
S x EB	-.18	.14	-.09	1.69	
S x PSE	-.10	.14	-.05	.54	
S x A	.08	.12	.04	.35	
S x CG	-.24	.53	-.04	.21	
EB x PSE	-.03	.06	-.03	.22	
EB x A	-.01	.05	-.01	.02	
EB x CG	-.28	.22	-.10	1.64	
PSE x A	.02	.06	.02	.08	
PSE x CG	.20	.23	.06	.72	
A x CG	-.27	.23	-.08	1.35	

***$p < .001$.

Note: No higher order interactions were significant in Steps 3, 4, or 5 of the analyses.

Table A15. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Epistemological Beliefs, Physics Self-efficacy, and Ability:Taking Physics Will Not Decrease My GPA (N=284).

Variable	B	SE B	ß	F	ΔR^2
Step 1				9.41***	.17***
Gender (G)	-.20	.11	-.10	2.98	
School (S)	-.12	.12	-.05	.98	
Epistemological beliefs (EB)	-.26	.06	-.25	15.67***	
Physics self-efficacy (PSE)	.19	.07	.17	8.67	
Academic ability (A)	.13	.06	.13	4.63	
Career goal (CG)	.22	.22	.06	1.00	
Step 2				3.51	.05
Gender	-.15	.14	-.07	1.07	
School	-.11	.41	-.05	.07	
Epistemological beliefs	-.36	.23	-.37	2.54	
Physics self-efficacy	.26	.25	.24	1.08	
Academic ability	-.01	.21	-.01	.00	
Career goal (CG)	.20	.81	.05	.07	
G x S	.07	.26	.05	.07	
G x EB	.07	.14	.12	.32	
G x PSE	.01	.15	.01	.00	
G x A	.04	.13	-.06	.08	
G x CG	.18	.61	.07	.09	
S x EB	.09	.16	.05	.30	
S x PSE	.05	.16	.02	.09	
S x A	.08	.15	.04	.31	
S x CG	-.79	.62	-.12	1.65	
EB x PSE	-.07	.07	-.07	1.21	
EB x A	.12	.06	.13	3.82	
EB x CG	.20	.25	.07	.64	
PSE x A	.15	.07	.14	4.20	
PSE x CG	-.05	.27	.01	.03	
A x CG	.21	.27	.06	.64	

***$p<.001$.

Note: No higher order interactions were significant in Steps 3, 4, or 5 of the analyses.

Table A16. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Physics is Useful in Everyday Life (N = 619).

Variable	B	SE B	ß	F	ΔR^2
Step 1				43.61***	.26***
Gender (G)	-.04	.07	-.01	.15	
School (S)	.13	.10	.05	1.78	
Physics self-efficacy (PSE)	.49	.04	.48	174.34***	
Academic ability (A)	.06	.04	.06	2.67	
Career group (CG)	-.01	.12	-.00	.01	
Step 2				16.15***	.02
Gender	-.09	.08	-.05	1.44	
School	-.09	.30	-.03	.10	
Physics self-efficacy	.43	.12	.42	11.85***	
Academic ability	.41	.11	.42	13.66***	
Career goal	-.95	.36	-.28	6.81	
G x S	.13	.19	.08	.48	
G x PSE	.05	.08	.07	.38	
G x A	-.24	.07	-.38	11.28***	
G x CG	.70	.27	.28	.00	
S x PSE	.03	.12	.01	.09	
S x A	-.07	.11	-.03	.46	
S x CG	-.01	.38	-.00	.00	
PSE x A	.01	.04	.01	.13	
PSE x CG	-.14	.14	-.05	.98	
A x CG	.16	.15	.04	1.03	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A17. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Physics is Hard Work (N = 617).

Variable	B	SE B	ß	F	ΔR^2
Step 1				19.68***	.14***
Gender (G)	.29	.08	.14	14.37***	
School (S)	.07	.11	.02	.43	
Physics self-efficacy (PSE)	.35	.04	.34	73.13***	
Academic ability (A)	-.04	.04	-.04	1.16	
Career goal (CG)	-.25	.13	-.07	3.41	
Step 2				7.52***	.02
Gender	.30	.09	.15	12.81***	
School	.22	.33	.08	.44	
Physics self-efficacy	.27	.14	.26	3.83	
Academic ability	-.10	.12	-.10	.64	
Career goal	.01	.40	.00	.00	
G x S	-.10	.21	-.06	.24	
G x PSE	.03	.09	.05	.16	
G x A	.04	.08	.06	.26	
G x CG	-.16	.30	-.06	.29	
S x PSE	-.09	.13	-.03	.50	
S x A	.07	.12	.02	.34	
S x CG	-.07	.42	-.01	.03	
PSE x A	-.12	.04	-.12	9.06	
PSE x CG	.23	.16	.07	2.18	
A x CG	-.25	.17	-.07	2.18	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A18. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Taking Physics Will Allow Me to Take Advanced Courses in College (N = 619).

Variable	B	SE B	ß	F	ΔR^2
Step 1				55.16	.31***
Gender (G)	.06	.07	.04	.94	
School (S)	-.13	.09	-.05	1.90	
Physics self-efficacy (PSE)	.50	.04	.49	192.71***	
Academic ability (A)	.14	.03	.14	15.87***	
Career goal (CG)	.06	.12	.02	.26	
Step 2				18.85***	.01
Gender	.07	.07	.04	.84	
School	-.25	.29	-.09	.71	
Physics self-efficacy	.53	.12	.53	19.48***	
Academic ability	.32	.11	.33	8.95	
Career goal	.24	.35	.07	.48	
G x S	.06	.19	.04	.11	
G x PSE	-.02	.07	-.04	.11	
G x A	-.14	.07	-.21	3.71	
G x CG	-.18	.26	-.07	.48	
S x PSE	-.06	.11	-.02	.29	
S x A	.11	.11	.04	1.03	
S x CG	.24	.37	.03	.44	
PSE x A	.02	.03	.02	.33	
PSE x CG	.06	.14	.02	.19	
A x CG	-.09	.15	-.02	.35	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A19. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Taking Physics Will Be Fun (N = 619).

Variable	B	SE B	ß	F	ΔR^2
Step 1				27.42***	.18***
Gender (G)	-.00	.07	-.00	.00	
School (S)	.09	.10	.03	.77	
Physics self-efficacy (PSE)	.45	.04	.44	129.30***	
Academic ability (A)	-.07	.04	-.07	3.68	
Career goal (CG)	.03	.13	.01	.06	
Step 2				9.64***	.01
Gender	-.08	.08	-.04	.95	
School	-.44	.32	-.16	1.86	
Physics self-efficacy	.38	.13	.37	8.31	
Academic ability	-.01	.12	-.01	.00	
Career goal	-.36	.39	-.10	.84	
G x S	.36	.21	.20	3.11	
G x PSE	.04	.08	.07	.29	
G x A	-.05	.08	-.08	.45	
G x CG	.29	.29	.11	1.00	
S x PSE	.03	.13	.01	.05	
S x A	.14	.12	.05	1.35	
S x CG	-.22	.41	-.02	.29	
PSE x A	.02	.04	.02	.21	
PSE x CG	.11	.15	.04	.56	
A x CG	-.10	.17	-.03	.37	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A20. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Physics Will Help Me in My Future Occupation (N = 619).

Variable	B	SE B	ß	F	ΔR^2
Step 1				42.18***	.26***
Gender (G)	.00	.07	.00	.00	
School (S)	.05	.10	.02	.22	
Physics self-efficacy (PSE)	.50	.04	.49	174.83***	
Academic ability (A)	-.02	.04	-.02	.36	
Career goal (CG)	.41	.12	.12	11.32***	
Step 2				15.53***	.02
Gender	-.05	.08	-.03	.40	
School	-.29	.30	-.10	.92	
Physics self-efficacy	.40	.12	.39	10.08	
Academic ability	.20	.11	.21	3.32	
Career goal	-.02	.37	-.01	.01	
G x S	.24	.19	.14	1.55	
G x PSE	.09	.08	.14	1.39	
G x A	-.16	.07	-.25	4.87	
G x CG	.27	.27	.11	1.00	
S x PSE	-.07	.12	-.02	.38	
S x A	-.07	.11	-.11	.43	
S x CG	.14	.38	.02	.14	
PSE x A	.09	.04	.10	6.65	
PSE x CG	-.11	.14	-.04	.63	
A x CG	.22	.16	.06	1.96	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A21. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Taking Physics Will Require Extra Time (N = 617).

Variable	B	SE B	ß	F	ΔR^2
Step 1				5.03***	.04***
Gender (G)	.23	.08	.11	7.77	
School (S)	-.26	.11	-.09	5.39	
Physics self-efficacy (PSE)	.14	.04	.14	10.66***	
Academic ability (A)	-.09	.04	-.09	4.61	
Career goal (CG)	-.14	.14	-.04	.97	
Step 2				2.50***	.02
Gender	.22	.09	.11	6.12	
School	-.41	.35	-.14	1.34	
Physics self-efficacy	.22	.15	.21	2.21	
Academic ability	-.09	.13	-.09	.50	
Career goal	.04	.43	.01	.01	
G x S	.15	.23	.08	.41	
G x PSE	-.05	.09	-.07	.28	
G x A	-.02	.09	-.03	.04	
G x CG	-.12	.32	-.05	.14	
S x PSE	-.18	.14	-.06	1.68	
S x A	-.00	.13	-.00	.00	
S x CG	-.48	.45	-.05	1.16	
PSE x A	-.05	.04	-.05	1.69	
PSE x CG	-.04	.17	-.01	.05	
A x CG	.35	.18	.09	3.68	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A22. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Taking Physics Will Not Decrease My GPA (N = 615).

Variable	B	SE B	ß	F	ΔR^2
Step 1				14.05***	.10***
Gender (G)	-.03	.08	-.01	.14	
School (S)	.11	.11	.04	.95	
Physics self-efficacy (PSE)	.26	.04	.25	37.55***	
Academic ability (A)	.13	.04	.13	9.75	
Career goal (CG)	.13	.14	.04	.91	
Step 2				7.73***	.06***
Gender	-.00	.08	-.00	.00	
School	.29	.33	.10	.76	
Physics self-efficacy	.32	.14	.31	5.46	
Academic ability	.26	.12	.26	4.37	
Career goal (CG)	.07	.40	.02	.03	
G x S	-.08	.21	-.04	.13	
G x PSE	-.02	.09	-.33	.07	
G x A	-.09	.08	-.14	1.32	
G x CG	.03	.30	.01	.01	
S x PSE	.11	.13	.04	.70	
S x A	-.01	.12	-.00	.00	
S x CG	-.61	.42	-.06	2.17	
PSE x A	.24	.04	.24	36.26***	
PSE x CG	.18	.15	.06	1.42	
A x CG	-.06	.17	-.02	.12	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A23. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Taking Physics Will Help Me Get into a Good College.

Variable	B	SE B	ß	F	ΔR^2
Step 1				56.53***	.32***
Gender (G)	.17	.07	.08	6.18	
School (S)	-.00	.09	-.00	.00	
Physics self-efficacy (PSE)	.50	.04	.49	193.29***	
Academic ability (A)	.14	.03	.14	15.26***	
Career goal (CG)	-.15	.12	-.04	1.59	
Step 2				19.98***	.02
Gender	.16	.08	.08	4.48	
School	-.18	.29	-.07	.39	
Physics self-efficacy	.63	.12	.61	26.98***	
Academic ability	.43	.11	.44	15.97***	
Career goal	-.15	.36	-.04	.18	
G x S	.11	.19	.06	.36	
G x PSE	-.14	.13	-.20	1.06	
G x A	-.21	.07	-.32	8.98	
G x CG	-.05	.26	-.02	.04	
S x PSE	-.04	.11	-.01	.13	
S x A	-.01	.11	-.00	.01	
S x CG	.32	.37	.03	.75	
PSE x A	.03	.03	.03	.74	
PSE x CG	-.05	.14	-.02	.12	
A x CG	.07	.15	.02	.25	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A24. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Science Teacher Influence (N = 619).

Variable	B	SE B	ß	F	ΔR²
Step 1				37.80***	.24***
Gender (G)	.16	.07	.08	5.15	
School (S)	.51	.10	.18	27.06***	
Physics self-efficacy (PSE)	.41	.04	.41	118.00***	
Academic ability (A)	.05	.04	.05	1.63	
Career goal (CG)	-.04	.12	-.01	.11	
Step 2				13.15***	.01
Gender	.17	.08	.09	4.68	
School	.33	.31	.12	1.16	
Physics self-efficacy	.43	.13	.42	11.10***	
Academic ability	.12	.11	.12	1.02	
Career goal	.35	.38	.10	.87	
G x S	.13	.20	.07	.41	
G x PSE	.00	.08	.00	.00	
G x A	-.07	.03	.10	.43	
G x CG	-.28	.28	-.11	1.07	
S x PSE	.15	.12	.05	1.45	
S x CG	-.19	.39	-.02	.24	
S x A	-.00	.11	-.00	.00	
PSE x A	.05	.04	.05	1.96	
PSE x CG	-.19	.15	-.06	1.64	
A x CG	.11	.16	.03	.49	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A25. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Good Friend Influence (N = 618).

Variable	B	SE B	ß	F	ΔR^2
Step 1				16.53***	.12***
Gender (G)	.15	.08	.07	3.64	
School (S)	-.06	.11	-.02	.29	
Physics self-efficacy (PSE)	.32	.04	.31	61.05***	
Academic ability (A)	.05	.04	.05	1.43	
Career goal (CG)	.08	.13	.02	.33	
Step 2				6.07***	.01
Gender	.19	.09	.09	4.57	
School	-.06	.34	-.02	.03	
Physics self-efficacy	.27	.14	.26	3.76	
Academic ability	.20	.13	.20	2.53	
Career goal	.65	.41	.18	2.50	
G x S	.02	.22	.01	.01	
G x PSE	.03	.09	.04	.10	
G x A	-.10	.08	-.16	1.59	
G x CG	-.41	.30	-.16	1.79	
S x PSE	.16	.13	.05	1.44	
S x A	-.05	.12	-.02	.19	
S x CG	-.66	.42	-.07	2.43	
PSE x A	.03	.04	.03	.48	
PSE x CG	.06	.16	.02	.13	
A x CG	.04	.17	.01	.04	

***$p < .001$.
Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A26. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, Ability, and Career Goal: College Admissions Officer Influence N = 619).

Variable	B	SE B	ß	F	ΔR^2
Step 1				33.97***	.22****
Gender (G)	.02	.07	.01	.05	
School (S)	-.12	.10	-.05	1.60	
Physics self-efficacy (PSE)	.43	.04	.42	122.47***	
Academic ability (A)	.10	.04	.11	8.65	
Career goal (CG)	.03	.13	.01	.05	
Step 2				12.80	.02
Gender	.01	.08	.01	.03	
School	-.18	.31	-.07	.36	
Physics self-efficacy	.55	.13	.54	18.51***	
Academic ability	.08	.12	.08	.48	
Career goal	-.15	.38	-.04	.15	
G x S	.07	.20	.04	.12	
G x PSE	-.08	.08	-.12	.96	
G x A	.02	.08	.03	.09	
G x CG	.16	.28	.06	.32	
S x PSE	.19	.12	.06	2.33	
S x A	-.11	.11	-.04	.92	
S x CG	-.74	.39	-.08	3.57	
PSE x A	.12	.04	.12	10.56***	
PSE x CG	-.09	.15	-.03	.42	
A x CG	.23	.16	.06	2.06	

*** $p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A27. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, Ability, and Career Goal: Mother Influence (N = 617).

Variable	B	SE B	ß	F	ΔR^2
Step 1				40.29***	.25***
Gender (G)	.01	.07	.01	.04	
School (S)	-.27	.10	-.10	7.90	
Physics self-efficacy (PSE)	.47	.04	.46	153.38***	
Academic ability (A)	.09	.04	.09	5.93	
Career goal (CG)	-.03	.12	-.01	.06	
Step 2				14.26***	.01
Gender	.01	.08	.01	.02	
School	-.41	.31	-.15	1.75	
Physics self-efficacy	.63	.12	.61	24.27***	
Academic ability	.19	.11	.19	2.74	
Career goal	-.00	.37	-.00	.00	
G x S	.12	.20	.07	.37	
G x PSE	-.09	.08	-.14	1.44	
G x A	-.08	.07	-.12	1.09	
G x CG	-.01	.28	-.00	.00	
S x PSE	.03	.12	.01	.07	
S x A	.10	.11	.03	.76	
S x CG	-.46	.39	-.05	1.41	
PSE x A	.09	.04	.09	5.86	
PSE x CG	.08	.14	.02	.29	
A x CG	-.07	.16	-.02	.20	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A28. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, Ability, and Career Goal: Sibling Influence (N = 614).

Variable	B	SE B	ß	F	ΔR^2
Step 1				10.83***	.08***
Gender (G)	.03	.08	.02	.17	
School (S)	-.11	.11	-.04	.97	
Physics self-efficacy (PSE)	.27	.04	.26	40.97***	
Academic ability (A)	.01	.04	.01	.06	
Career goal (CG)	.29	.14	.08	4.45	
Step 2				4.18***	.01
Gender	.04	.09	.02	.21	
School	-.22	.35	-.08	.39	
Physics self-efficacy	.38	.14	.37	7.03	
Academic ability	-.11	.13	-.11	.75	
Career goal	.60	.42	.17	2.02	
G x S	.10	.22	.06	.20	
G x PSE	-.06	.09	-.09	.48	
G x A	.09	.09	.13	1.11	
G x CG	-.21	.31	-.09	.45	
S x PSE	.09	.14	.03	.44	
S x A	.02	.13	.01	.02	
S x CG	-.37	.44	-.04	.72	
PSE x A	.09	.04	.09	4.83	
PSE x CG	.01	.16	.00	.00	
A x CG	-.10	.18	-.03	.28	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A29. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, Ability, and Career Goal: Boyfriend/Girlfriend Influence (N = 614).

Variable	B	SE B	ß	F	ΔR^2
Step 1				6.59***	.05***
Gender (G)	-.03	.08	-.02	.15	
School (S)	-.16	.11	-.06	2.02	
Physics self-efficacy (PSE)	.19	.04	.18	18.41***	
Academic ability (A)	.05	.04	.05	1.23	
Career goal (CG)	.31	.14	.09	4.63	
Step 2				3.27***	.02
Gender	.03	.09	.02	.18	
School	-.06	.35	-.02	.04	
Physics self-efficacy	.32	.15	.31	4.91	
Academic ability	.05	.13	.05	.15	
Career goal	1.34	.43	.38	9.61	
G x S	-.03	.23	-.02	.02	
G x PSE	-.10	.09	-.515	1.20	
G x A	.02	.09	.02	.04	
G x CG	-.71	.32	-.27	4.88	
S x PSE	.18	.14	.06	1.74	
S x A	-.12	.13	-.04	.88	
S x CG	-.75	.44	-.08	2.84	
PSE x A	.04	.04	.04	.87	
PSE x CG	.05	.16	.02	.10	
A x CG	-.22	.18	-.06	1.49	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A30. Summary of Regression Analysis Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, Ability, and Career Goal: School Counselor Influence ($N = 619$).

Variable	B	SE B	ß	F	ΔR^2
Step 1				34.01***	.22***
Gender (G)	.10	.07	.05	2.07	
School (S)	.16	.10	.06	2.68	
Physics self-efficacy (PSE)	.40	.04	.39	103.81***	
Academic ability (A)	.14	.04	.15	14.72***	
Career goal (CG)	-.05	.13	-.02	.15	
Step 2				12.79***	.02
Gender	.13	.08	.06	2.45	
School	.14	.31	.05	.21	
Physics self-efficacy	.15	.13	.14	1.31	
Academic ability	.24	.12	.25	4.39	
Career goal	.30	.38	.08	.60	
G x S	-.01	.20	-.00	.00	
G x PSE	.15	.08	.22	3.25	
G x A	-.06	.08	-.09	.64	
G x CG	-.29	.28	-.11	1.05	
S x PSE	.37	.12	.12	9.10	
S x A	-.03	.11	-.01	.06	
S x CG	-.37	.40	-.04	.86	
PSE x A	.08	.04	.08	4.10	
PSE x CG	.18	.15	.06	1.50	
A x CG	-.06	.16	-.02	.16	

***$p < .001$.

Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

Table A31. Summary of Regression Analysis for Prediction of Attitude toward Physics Enrollment Determinants by Gender, School, Physics Self-efficacy, and Ability: Father Influence (N = 616).

Variable	B	SE B	ß	F	ΔR^2
Step 1				34.25***	.22***
Gender (G)	.03	.07	.01	.12	
School (S)	-.20	.10	-.07	4.03	
Physics self-efficacy (PSE)	.43	.04	.41	119.41***	
Academic ability (A)	.11	.04	.11	8.89	
Career goal (CG)	.14	.13	.04	1.30	
Step 2				12.66***	.02
Gender	.01	.08	.01	.03	
School	-.49	.31	-.18	2.42	
Physics self-efficacy	.57	.13	.56	19.36***	
Academic ability	.43	.12	.17	2.02	
Career goal	.39	.38	.11	1.04	
G x S	.24	.20	.13	1.43	
G x PSE	-.09	.08	-.13	1.15	
G x A	-.02	.08	-.04	.11	
G x CG	-.15	.28	-.06	.26	
S x PSE	.05	.12	.02	.19	
S x A	-.07	.11	-.02	.36	
S x CG	-.70	.40	-.07	3.09	
PSE x A	.11	.04	.12	9.29	
PSE x CG	.12	.15	.04	.61	
A x CG	-.22	.16	-.06	1.82	

***$p < .001$.
Note. Higher order interactions entered in Steps 3, 4, and 5 did not result in a significant increase in R^2 or in significant interaction effects..

APPENDIX B
QUESTIONNAIRES

Table B1. Preliminary Attitude Questionnaire

1. What do you believe are the advantages to you of enrolling in a physics class in high school?

2. What do you believe are the disadvantages to you of enrolling in a physics class in high school

3. What else do you think about when you think of enrollment in a physics class?.

4. Suppose you were considering taking a physics course during your sophomore, junior, or senior year of high school. There might be individuals or groups who would think you should or should not do this. Which individual people or groups of people come to mind when you consider taking a physics course? Check those groups or people below who might influence your decision. If we've missed someone who is important, please check "other" and indicate the relationship of that person to you.

________	best friend(s)	________	a high school counselor
________	boyfriend or girlfriend	________	brother or sister
________	other good friends	________	grandparent(s)
________	mother	________	college admissions officer
________	father	________	a scientist
________	science teacher	________	doctor or dentist
________	a teacher in a subject other than science		
________	other. What is the relationship of this person to you?____________________		

Table B2. Final Attitude toward Enrollment Questionnaire

Please print your name on the slip of paper attached to your answer sheet. Fill in the appropriate circle on the answer sheet to indicate whether you are male or female. *For the first 3 questions, fill in the bubble on the answer sheet that indicates your best answer.*

1. What do you plan to do when you leave high school?
   A. attend a 4-year college and then go to graduate or professional school
   B. attend a 4-year college
   C. attend a 2-year college like DMACC for an associate degree
   D. attend a nursing or technical job-training program at an area college, nursing school, or technical school
   E. attend a school for training in clerical skills
   F. go right to work
   G. go into the military
   H. I don't have any idea yet.

2. What type of career are you considering? (choose ONE best answer)
   A. Engineering/physical science (such as geology, physics, astronomy, meteorology)
   B. Math/computer science
   C. Health field (such as medical doctor, dentist, RN, physician's assistant)
   D. Liberal arts or fine arts field (such as psychology, sociology,law, anthropology, English, drama, music, graphic art, fine art)
   E. Education
   F. Business (such as management, accounting, and sales)
   G. Biological science field (such as biology, zoology, botany)
   H. Agriculture
   I. Skilled trade (such as carpenter, plumber, electrician, mason)
   J. Other (such as daycare provider, hair stylist, bus driver, factory worker, clerical worker, homemaker)

3. What is your race?
   A. Black/ African-American
   B. Mexican-American
   C. Asian/ Pacific Islander
   D. Caucasian/ White
   E. Native American
   F. Other

For the remainder of the statements, fill in the bubble on the computer sheet that shows the extent to which you agree or disagree. There are no right or wrong answers for these questions. We want to know what you really believe about school and about learning.

4. I intend to enroll in a physics class (besides grade 9 physical science) during high school.

   NO, definitely not 1 2 3 4 5 6 7 YES, I definitely will

5. I intend to enroll in a chemistry class during high school.

   NO, definitely not 1 2 3 4 5 6 7 YES, I definitely will

6. I intend to enroll in a biology class during high school.

   NO, definitely not 1 2 3 4 5 6 7 YES, I definitely will

7. My attitude toward my enrolling in a physics course during high school is

   Unfavorable 1 2 3 4 5 6 7 Favorable

8. My attitude toward my enrolling in a chemistry course during high school is

   Unfavorable 1 2 3 4 5 6 7 Favorable

9. My attitude toward my enrolling in a biology class during high school is

   Unfavorable 1 2 3 4 5 6 7 Favorable

10. Most people who are important to me think I

    Should NOT 1 2 3 4 5 6 7 Should

    take a physics class in high school.

11. Most people who are important to me think I 3

Should NOT 1 2 3 4 5 6 7 Should

take a chemistry class in high school

12. Most people who are important to me think I

Should NOT 1 2 3 4 5 6 7 Should

take a biology class in high school

13. My taking a physics class in high school will help me to learn concepts that will be useful in my everyday life.

Unlikely 1 2 3 4 5 6 7 Likely

14. Learning concepts that are useful in everyday life is

Bad 1 2 3 4 5 6 7 Good

15. My taking a high school physics class means that I will have to work very hard to understand the new concepts taught.

Unlikely 1 2 3 4 5 6 7 Likely

16. Working hard to understand new concepts is

Bad 1 2 3 4 5 6 7 Good

17. Taking high school physics will allow me to take more advanced courses when I get to college.

Unlikely 1 2 3 4 5 6 7 Likely

18. Taking more advanced courses when I get to college is

Bad 1 2 3 4 5 6 7 Good

19. My taking a high school physics class will result in my getting a lot of enjoyment and having a lot of fun.

Unlikely 1 2 3 4 5 6 7 Likely

20. Enjoying myself and having a lot of fun is

Bad 1 2 3 4 5 6 7 Good

21. Taking a high school physics class will help me in my future occupation.

Unlikely 1 2 3 4 5 6 7 Likely

22. Doing things that will help me with my future occupation is

Bad 1 2 3 4 5 6 7 Good

23. My taking a high school physics class will require a lot of extra time that I could have used for other classes or activities.

Unlikely 1 2 3 4 5 6 7 Likely

24. Spending a lot of time on one class at the expense of other activities is

Bad 1 2 3 4 5 6 7 Good

25. My taking a high school physics class will decrease my GPA.

Unlikely 1 2 3 4 5 6 7 Likely

26. Decreasing my GPA is

Bad 1 2 3 4 5 6 7 Good

27. Taking a high school physics class will help me get into a good college.

Unlikely 1 2 3 4 5 6 7 Likely

28. My getting into a good college is

Bad 1 2 3 4 5 6 7 Good

29. My science teacher thinks that I should enroll in a physics class during high school.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

30. Generally speaking, I want to do what my science teacher thinks I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

31. My good friends think that I should enroll in a physics class during high school.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

32. Generally speaking, I want to do what my good friends think I should do. 5

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

33. College admissions officers think that I should enroll in a physics class during high school.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

34. Generally speaking, I want to do what college admissions officers think I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

35. My mother thinks that I should enroll in a physics class during high school.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

36. Generally speaking, I want to do what my mother thinks I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

37. My brother or sister thinks that I should enroll in a physics class during high school

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

38. Generally speaking, I want to do what my brother or sister thinks that I should do

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

39. My boyfriend/girlfriend thinks that I should enroll in a physics class during high school

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

40. Generally speaking, I want to do what my boyfriend/girlfriend thinks I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

41. My high school counselor thinks that I should enroll in a physics class during high school.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

42. Generally speaking, I want to do what my high school counselor thinks I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

43. My father thinks that I should enroll in a physics class during high school. 6

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

44. Generally speaking, I want to do what my father thinks I should do.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

45. I could successfully complete the work required in a high school physics class.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

46. Successful completion of the work required in a high school physics class is important to my future.

Definitely NOT important 1 2 3 4 5 6 7 Definitely very important

47. I could successfully complete the work required in a high school chemistry class.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

48. Successful completion of the work required in a high school chemistry class is important to my future.

Definitely NOT important 1 2 3 4 5 6 7 Definitely very important

49. I could successfully complete the work required in a high school biology class.

Definitely NOT 1 2 3 4 5 6 7 Definitely YES

50. Successful completion of the work required in a high school biology class is important to my future.

Definitely NOT important 1 2 3 4 5 6 7 Definitely very important

Use the following scale to indicate your answers to the next 31 questions: 7

Strongly Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Strongly Agree
1	2	3	4	5	6

51. It is hard to learn from a textbook unless you start at the beginning and learn one chapter at a time.

52. If I can't understand something right away, I will keep on trying.

53. The best thing about a science course is that most problems have only one right answer.

54. You will get mixed up if you try to combine new ideas in a textbook with what you already know.

55. I like it when experts disagree.

56. Some people are just born smart, others are born dumb.

57. Being a good student generally involves memorizing facts.

58. What students learn from a textbook depends on how they study it.

59. You can not learn anything more from a textbook by reading it twice.

60. Truth never changes.

61. A class in study skills would probably help slow learners.

62. Learning something really well takes a long time.

63. Thinking about what a textbook says is more important than memorizing what a textbook says.

64. Working hard on a difficult problem only pays off for the really smart students.

65. An expert is someone who is really born smart in something.

66. Successful students understand things quickly.

67. In order to understand what a sentence really means, you have to know the whole story behind it.

Strongly Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Strongly Agree	8
1	2	3	4	5	6	

68. I really do not like listening to teachers who can not seem to make up their minds about what they really believe.

69. If I can not understand something quickly, it usually means I will never understand it.

70. Scientists can get to the truth if they just keep searching for it.

71. Most words have one clear meaning.

72. If I am ever going to be able to understand something, it will make sense to me the first time I hear it.

73. Today's facts may be tomorrow's fiction.

74. To me, studying means getting the big ideas from the textbook rather than the details.

75. The really smart students don't have to work hard to do well in school.

76. There is only one thing you can be sure of: that nothing is sure!

77. If I find the time to re-read a textbook chapter, I get a lot more out of it the second time.

78. Students who are "average" in school will remain "average" for the rest of their lives.

79. If scientists try hard enough, they can find the truth to almost everything.

80. Getting ahead takes a lot of work.

81. The knowledge of "how to study" is usually learned as we grow older.

APPENDIX C
PRELIMINARY QUESTIONNAIRE SORTS

Table C1. Preliminary Questionnaire Content Analysis for Suburban District

ANKENY CARD SORT

Category	f	cf	c%
1. The information you learn is useful in your everyday life	17	17	24
It helps you understand stuff that happens in everyday life	9		
Physics will help you in the future	3		
We might be learning stuff we may never use in our whole life	2		
The material you learn	2		
It will help me with other classes	1		
2. It is difficult	13	30	42
Physics is hard work	8		
Physics is hard to understand	5		
3. It will help with college	8	38	53
Allows you to take more advanced courses in college	3		
Helps in college classes	2		
Helps to get into college	1		
Easier than taking it in college	1		
Advantage to taking it early	1		

Category	f	cf	c%
4. Don't like it; it's boring	7	45	63
I don't like it	2		
It needs to be fun	2		
It's boring	1		
I hate school, and this is part of school	1		
I don't care about physics	1		
5. It is important to my future occupation	6	51	71
It will be useful in my future career	3		
It will affect my occupation	1		
Some occupations don't use this information	1		
Getting a good job	1		
6. It will require a lot of time	5	56	79
7. It may decrease your GPA	4	60	85
8. It is related to math skills	4	64	90
It is required	3		
Misc 4			

Category	f	cf	c%
Subjective Norms sort			
1. Mother	15	15	15
2. Science teacher	15	30	29
3. Good friends	12	42	41
4. High school counselor	11	53	52
5. Father	10	63	62
6. College Admissions off.	10	73	72
7. Boyfriend/girlfriend	8	81	79
8. Sibling	7	89	87
9. Scientist	5	94	92
10. Teacher (not science)	4	98	96
11. Grandparents	2	100	98
12. Doctor or dentist	2	102	100

Table C2. Preliminary Questionnaire Content Analysis for Rural District

South Hamilton card sort

Category	f	cf	c%
Learning physics will be useful in my everyday life.	19	19	29
Learn about the world (6)			
Learn in general (5)			
Learn about science (5)			
Physics may not be useful (3)			
Physics is really hard	9	28	43
Taking physics will take a lot of time that I could have used for other activities.	7	35	56
Can't take other classes(4)			
Lots of homework (2)			
Lots of time(1)			
I may need physics in my future career.	6	41	65
Taking high school physics will help you once you get to college.	6	47	72
(easier than taking it in college (1)			
Taking physics will help you get into a good college	3	50	76
Taking physics will lower my GPA.	3	53	81
If I take physics, I'll be with people I like.	3	56	86
Teacher (2)			
Students (1)			
Taking physics will be fun.	3	59	91
I can get high school credits for taking physics.	2	61	94
Misc	4	65	100

Subjective Norms Sort - S. Hamilton

Category	f	cf	c%
Best friends	13	13	13
Mother	13	26	25
Father	13	39	38
Science teacher	12	51	49
Sibling	12	63	62
College admissions officer	9	72	71
A scientist	9	81	79
Boyfriend/girlfriend	6	87	
High school counselor	6	93	
Teacher in another subject	4	97	
Grandparents	3	100	
Dr.or dentist	2	102	

APPENDIX D
HUMAN SUBJECTS AND CONSENT FORMS

Information for Review of Research Involving Human Subjects
Iowa State University
(Please type and use the attached instructions for completing this form)

Title of Project Relationships of Self-Efficacy, ~~Personal~~ Epistemological Beliefs, and Attitudes to Intended Science Class Enrollment

I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are protected. I will report any adverse reactions to the committee. Additions to or changes in research procedures after the project has been approved will be submitted to the committee for review. I agree to request renewal of approval for any project continuing more than one year.

Charlotte W. Haselhuhn — 2-7-95 — [signature]
Typed Name of Principal Investigator — Date — Signature of Principal Investigator

Psychology — W112 Lagomarcino — 294-2953
Department — Campus Address — Campus Telephone

Signatures of other investigators — Date — Relationship to Principal Investigator
[signature] — 2/7/95 — Major Professor

RECEIVED FEB 14 1995 ISU GRADUATE COLLEGE

Principal Investigator(s) (check all that apply)
☐ Faculty ☐ Staff ☒ Graduate Student ☐ Undergraduate Student

Project (check all that apply)
☐ Research ☒ Thesis or dissertation ☐ Class project ☐ Independent Study (490, 590, Honors project)

Number of subjects (complete all that apply)
1000 # Adults, non-students ___ # ISU student ___ # minors under 14 ___ other (explain)
750 # minors 14 - 17

Brief description of proposed research involving human subjects: (See instructions, Item 7. Use an additional page if needed.)

Please refer to attached information.

(Please do not send research, thesis, or dissertation proposals.)

8. Informed Consent: ☒ Signed informed consent will be obtained. (Attach a copy of your form.)
... consent will be obtained. (See instructions, item 8.)

Confidentiality of Data: Describe below the methods to be used to ensure the confidentiality of data obtained. (See instructions, item 9.)

Names will be attached to parent and student response forms until ITED test scores are matched to student responses. Names will then be removed and all student and parent information will be identified by code numbers.

What risks or discomfort will be part of the study? Will subjects in the research be placed at risk or incur discomfort? Describe any risks to the subjects and precautions that will be taken to minimize them. (The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological or emotional risk. See instructions, item 10.)

No risk or discomfort to participants is anticipated.

CHECK ALL of the following that apply to your research:

- [ ] A. Medical clearance necessary before subjects can participate
- [ ] B. Samples (Blood, tissue, etc.) from subjects
- [ ] C. Administration of substances (foods, drugs, etc.) to subjects
- [ ] D. Physical exercise or conditioning for subjects
- [ ] E. Deception of subjects
- [ ] F. Subjects under 14 years of age and/or [X] Subjects 14 - 17 years of age
- [ ] G. Subjects in institutions (nursing homes, prisons, etc.)
- [X] H. Research must be approved by another institution or agency (Attach letters of approval)

If you checked any of the items in 11, please complete the following in the space below (include any attachments):

Items A - D Describe the procedures and note the safety precautions being taken.

Item E Describe how subjects will be deceived; justify the deception; indicate the debriefing procedure, including the timing and information to be presented to subjects.

Item F For subjects under the age of 14, indicate how informed consent from parents or legally authorized representatives as well as from subjects will be obtained.

Items G & H Specify the agency or institution that must approve the project. If subjects in any outside agency or institution are involved, approval must be obtained prior to beginning the research, and the letter of approval should be filed.

Last Name of Principal Investigator Haselhuhn

C klist for Attachments and Time Schedule

The following are attached (please check):

12. [X] Letter or written statement to subjects indicating clearly:
   a) purpose of the research
   b). the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
   c) an estimate of time needed for participation in the research and the place
   d) if applicable, location of the research activity
   e) how you will ensure confidentiality
   f) in a longitudinal study, note when and how you will contact subjects later
   g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [X] Consent form (if applicable)

14. [ ] Letter of approval for research from cooperating organizations or institutions (if applicable)

15. [X] Data-gathering instruments (See attached information.)

16. Anticipated dates for contact with subjects:

First Contact	Last Contact
3/1/95	5/31/96
Month / Day / Year	Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

5/31/96

Month / Day / Year

18. Signature of Departmental Executive Officer — Date — Department or Administrative Unit

Camilla Benbow (By Dan Russell) — 2/13/95 — Psychology

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith	3-7-95	PMKeith
Name of Committee Chairperson	Date	Signature of Committee Chairperson

To: Dr. Patricia Keith

From: Charlotte Haselhuhn

Date: 3/7/95

Re: Proposal "Relationships of self-efficacy..."

Attached is a memorandum from Dr. Dan Russell, Chair of the Psychology Department Human Subjects Committee. The department committee has approved the use of student consent for my study.

I would like to make one more modification in the procedure of my study. I am measuring intended course enrollment of high school freshman, and I would like to be able to look at the relationship between intended enrollment and actual enrollment. So, instead of destroying all identification on 5/31/96 as I had originally indicated, I would like to keep a list of code numbers and students names until 7/31/98. The list would be kept on disk, and only the principal investigator would have access to it. After actual courses taken were matched with intended enrollment, all identifiers would be destroyed. This information would be included in the parent information letter and in the informed consent form signed by the students. Copies of student consent forms and parent information letters are attached.

Approved with the understanding that parents will be informed about the use of ITED scores.

P. Keith
3-7-95

DISTRICT PERMISSION FORM

As an administrator in the Cedar Rapids Community School District, I agree to allow ninth-grade students in this district to participate in the science attitude study conducted by Charlotte Haselhuhn and Dr. Thomas Andre of Iowa State University. I understand that all participating students will be asked to complete one 81-item attitude questionnaire. Standardized test scores and course enrollment information will be obtained from students' permanent records. All information collected about individual students will be confidential, but I will receive summary information about the results. Summary information collected in the district may be used in a published report, but nothing will reveal information regarding individual students, teachers, or school districts.

Signature Steven G. Chambliss

Printed Name Steven Chambliss

Title Executive Director - Middle & High Schools Date May 17, 1995

DISTRICT PERMISSION FORM

As an administrator in the Jefferson-Scranton Community School District, I agree to allow ninth-grade students in this district to participate in the science attitude study conducted by Charlotte Haselhuhn and Dr. Thomas Andre of Iowa State University. I understand all participating students will be asked to complete one 81-item questionnaire. Standardized test scores and student course-participation information will be obtained from students' permanent records. All information collected about individual students will be confidential, but I will receive summary information about the results. Summary information collected in the district may be used in a published report, but nothing will reveal information regarding individual students, teachers, or school districts.

Signature Dianne Blackmer

Printed Name Dianne Blackmer

Title Curriculum Director Date 4/28/95

DISTRICT PERMISSION FORM

As an administrator in the Union Community School District, I agree to allow ninth-grade students in district to participate in the science education study conducted by Charlotte Haselhuhn and Dr. Thomas Andre of Iowa State University. I understand that some of the students will be asked to completed a brief open-ended questionnaire, and that others will be asked to complete two additional questionnaires. Parents of students will also have the opportunity to complete a questionnaire. All information collected about individual students will be confidential, but I will receive summary information about the results. Summary information collected in the district may be used in a published report, but no information from the data will reveal information regarding individual students, teachers, or school districts.

Signature Neil R. Mullen

Printed Name Neil R. Mullen

Title Principal Date 3-5-95

DISTRICT PERMISSION FORM

As an administrator in the Ankeny Community School District, I agree to allow ninth-grade students in district to participate in the science education study conducted by Charlotte Haselhuhn and Dr. Thomas Andre of Iowa State University. I understand that some of the students will be asked to completed a brief open-ended questionnaire, and that others will be asked to complete two additional questionnaires. Parents of students will also have the opportunity to complete a questionnaire. All information collected about individual students will be confidential, but I will receive summary information about the results. Summary information collected in the district may be used in a published report, but no information from the data will reveal information regarding individual students, teachers, or school districts.

Signature Gary Ratigan

Printed Name GARY RATIGAN

Title Principal Date 2-20-95

DISTRICT PERMISSION FORM

As an administrator in the South Hamilton Community School District, I agree to allow ninth-grade students in this district to participate in the science attitude study conducted by Charlotte Haselhuhn and Dr. Thomas Andre of Iowa State University. I understand that some of the students will be asked to complete a brief open-ended questionnaire, and that all participating students will be asked to complete one additional questionnaire. Standardized test scores will be obtained from students' permanent records. All information collected about individual students will be confidential, but I will receive summary information about the results. Summary information collected in the district may be used in a published report, but nothing will reveal information regarding individual students, teachers, or school districts.

Signature Carol McLaughlin

Title Curriculum & Technology Dir Date 4-7-95

STUDENT CONSENT FORM - Cedar Rapids Jefferson

We are interested in how students make decisions about taking science classes in high school. You have the opportunity to participate in a study that will help to provide some answers to this question.

All students who participate in the study will complete one 81-item questionnaire. The questionnaire consists of items concerning your attitudes toward taking science classes. The questionnaire will be completed during one science class period.

As part of this study, we will compare information from standardized test scores that are contained in your permanent records with some of your responses on the questionnaires. In order to match standardized test scores with questionnaires, we ask you to print your name on the small sheet of paper attached to the questionnaire answer sheet. This piece of paper will be removed and destroyed after the records are matched, and you will be assigned a code number. We will keep your code number and your name together in a confidential file until you graduate from high school. At the time that you graduate, we will match the science classes you now plan to take with what you have actually completed. At that time, your name will be removed from all the material associated with this study.

All of your responses are completely confidential. You may choose not to have your questionnaire used in the study. Your grades will not be affected in any way.

The principal investigator, Charlotte Haselhuhn, or the co-investigator will be happy to answer any questions concerning this study.

Thank you for your cooperation!

Charlotte W. Haselhuhn. Ed.S.
Principal Investigator
Department of Psychology
Iowa State University
Ames, IA 50011
515-294-2953

Thomas Andre, Ph.D.
Co-investigator
Department of Psychology
Iowa State University
Ames, IA 50011
515-294-1754

I have read and understood the above information about the science class attitude study. I agree to participate in this study. I understand that I may choose not to have my questionnaire included in the study.

Name (print)____

Signature ______________________________ Date ______________

March 15, 1995

Dear Parent or Guardian:

The math and science courses that high school students choose to take have may have a major impact on their future careers. We are interested in how students make decisions about taking science classes in high school. Your 9th grade son or daughter has the opportunity to participate in a study at Ankeny High School that will help to answer this question.

All students who choose to participate in the study will complete a questionnaire and a portion of the participating students will complete an additional short, open-ended set of questions. The questionnaire will consist of about 50 items concerning specific attitudes toward taking science classes. Students will be asked to respond to statements such as:

"My attitude toward my enrollment in a physics class during high school is:
unfavorable _1_ _2_ _3_ _4_ _5_ _6_ _7_ favorable."

One class will be selected at random to respond to a brief additional set of questions such as the following: "What do you believe are the advantages of enrolling in a physics class within the next three years?" This portion of the study will require about 10 minutes of time and will be conducted during a regular science class period.

Students' responses to the questionnaire items will be matched with their standardized science and math achievement scores, and with future course enrollment information. All of your child's responses are confidential. Your son or daughter will be given information about the study and will be able to decide if he or she wishes to participate in the study. Participation in the study is expected to take half of one science class period.

We are interested in your ideas about science participation as well as those of your son or daughter. Included with this letter is a brief questionnaire concerning your opinions. If you choose to participate, simply indicate your responses on the questionnaire and return it to your 9th grader's science teacher. The questionnaires are marked Mother or Father at the top of the form. Step-parents and guardians who live with the student are encouraged to respond if appropriate. The parent questionnaires should be sealed in the enclosed envelope before they are returned to the science teacher, in order to maintain the confidentiality of your responses. The names of students whose parents return a completed questionnaire will be entered into a lottery for a prize of $50 to be awarded to the student whose name is drawn on March 31, 1995!

This study has been approved by Dr. Gary Ratigan, Principal of Ankeny High School. The principal investigator, Charlotte Haselhuhn, or the co-investigator will be happy to answer any questions concerning this study. Copies of all questions used in the study may be obtained by writing or calling the principal investigator.

Thank you for your cooperation!

Thomas Andre

Charlotte W. Haselhuhn. Ed.S.
Principal Investigator
Department of Psychology
Iowa State University
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